HD-11 Winchester

Disk System

Users Manual

Charles River Data Systems, Inc.
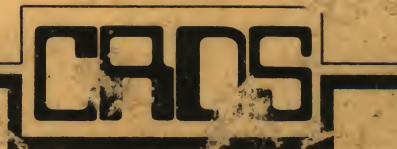
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PDP-11	RX02
RT-11	RL01
LSI-11	

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HD-11 PRELIMINARY USERS' MANUAL

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Section 1

INTRODUCTION

1.1 GENERAL

The CRDS HD-11 is a 21-megabyte formatted fixed disk system that utilizes Winchester technology to achieve high storage capacity at a low cost. It is compatible with both the LSI-11/2 and LSI-11/23 processors manufactured by Digital Equipment Corporation.

The HD-11-T includes an optional tape drive providing the system with a removable medium. This 3M cartridge tape drive may be used to provide backup or archival storage. The tape drive mounts inside the HD-11 chassis and utilizes the same power supply and controller/interface as the disk drive.

This unique packaging of a disk and tape drive in the same chassis -- sharing common electronics -- is a revolutionary concept in the minicomputer field. Combining the new, fast and inexpensive non-removable disk technology with another new technology, the 3M cartridge, provides a method of failsafing disk drives or allowing large off-line storage (tape libraries) to be created. Error correction (ECC) has been implemented on both the tape and disk peripherals for further reliability.

The HD-11 is completely software compatible with the RL01, allowing immediate and easy use of the product. No new handlers need to be integrated into your operating system, and the HD-11 executes DEC's RL01 disk diagnostics.

1.2 SCOPE OF MANUAL

This manual provides instructions for installing and operating the HD-11. In addition, a description of diagnostic procedures and simple maintenance procedures is provided.

This manual assumes a familiarity with the LSI-11 computer system. DEC's Microcomputer Processors Manual is suggested reading for users unacquainted with LSI-11 computers. If the HD-11 is to be used with CRDS's MF-211 systems, the MF-211 User's Manual should be consulted.

1.3 SUBSYSTEM CONFIGURATION

The HD-11 consists of the following subsystems:

        1   HC-210 Interface Card (plugs into LSI-11 backplane)
        1   HC-300 Controller Card (enclosed in HD-11 chassis)
        1   SA-4008 Winchester Disk Drive
        1   HD-402 Power Supply
        1   DEI-3400 Tape drive   (optional)

The HC-210 interface card is a quad card that plugs into any LSI-11 backplane, including the special 11/03-L backplane. It provides an interface to the LSI-11 for the four device registers, performs DMA functions to and from memory, handles interrupts, and contains a bootstrap memory 256 words long. The card has jumpers that allow selection of different device register addresses and interrupt vectors. A ribbon cable connects this card to the HC-300 controller card. This bus consists of 16 data signals and 10 control signals.

The HC-300 controller card mounts inside the HD-11 chassis. It has three 50-pin connectors that connect with

    (1) the HC-210 interface card,
    (2) the SA4008 disk drive, and
    (3) the DEI-3400 tape drive, if included.

The controller card controls all reading and writing to and from both the disk and tape drives. It is based around the 2901 family microprocessor chips and contains dual 256-byte buffers alternately used for data transfer with the disk and DMA logic.

The SA-4008 is a 29-megabyte (unformatted) drive manufactured by Shugart Associates. The drive utilizes Winchester technology and contains two non-removable platters. A band-driven head-actuation assembly moves eight heads to the desired track location. Two heads are located on each surface, thus reducing seek time.

The HD-402 provides all power required by the controller board (HC-300), the disk drive, and the tape drive. All supplies are capable of handling the tape drive even if the tape option was not ordered.

The DEI-3400 tape drive is manufactured by Data Electronics, Inc. The media used by these drives is known as a "3M cartridge". The 450-foot tape length is used allowing storage of up to 15.7 megabytes per tape cartridge. All information on the tape drive contained in this manual should be ignored by those users who have not elected the tape drive option.

1.4 SYSTEM COMPATIBILITY

In order to avoid adaptations to standard DEC operating software, the HD-11 was designed to be software compatible with DEC's RL01 drive. The HD-11 requires no modifications to DEC's device drivers to operate.

It is important to remember that the two devices are not identical. The RL01 is a removable media drive while the HD-11 is not. Also, the HD-11 has four times the storage capacity of the RL01. The user may store data on the HD-11 by referencing device names DL0, DL1, DL2, and DL3. These are not really four separate devices, but are four equal sections of one large disk. This provides an easy means of write-protecting some files on the disk. If desired, the user could modify the handler to make the drive appear as one large device.

The complete instruction set of this device is given in Section 4 of this manual.

1.5 HD-11 SPECIFICATIONS

Data Organization:

	Physical Drive	Logical Drive RL01 Subunit
bytes per sectors	256	256
sectors per track	60	40
tracks per head	202	256
heads per drive	8	2
bytes per track	15,360	10,240
bytes per cylinder	122,880	20,480
bytes per drive	20,971,520	5,242,880

Recording Technique:

method	MFM
bit density	5534 BPI
track density	172 TPI

Performance:

typical peak burst DMA transfer rate	1.3 us per word
typical sector data transfer rate	2.3 us per word
typical logical track transfer rate	5.2 us per word

	Over 4 RL01's	Over 1 RL01
track to track access	20	20
average seek time	60	32
maximum seek time	125	49
rotational speed	2964 rpm	
start time	90 seconds	

Operating Environment:

temperature	50°F to 105°F
relative humidity	8 to 80%
altitude	6000 ft.

Power:

HC-200:	+5 VCD $\pm$ 5% at 2 Amps
HD-11:	110 VAC, 50/60 Hz at 4 Amps, single phase
	230 VAC, 50/60 Hz at 2 Amps, single phase

Mechanical:

size:	10.5 inches high, 19 inches wide, 24 inches deep
weight:	approximately 100 pounds
mounting:	standard RETMA 19-inch rack mount on slides (provided)
cables:	standard length of 10 feet between interface card and HD-11 chassis. (other optional lengths available)

Section 2

UNPACKING AND INSTALLATION

2.1 UNPACKING

The HD-11 is shipped complete in a single carton. The carton must be opened
from the top (printing on sides of carton reading properly). Remove the
slides, manuals, cables, and any modules from the packing material. The top
section of the packing material may now be removed, exposing the HD-11 chassis.
Reach down through the cut-away sections to each side of the chassis, grasp
the unit from the bottom and lift it up and out.

The standard HD-11 unit should contain the following:

          1   HD-11 chassis
          1   HC-210 interface card
          1   this manual
          1   set of mounting slides
          1   line cord
          1   tape cartridge, containing CRDS disk and tape
                  diagnostic and transfer programs (if the
                  tape option was ordered)

Any discrepancy should be reported to CRDS immediately.

2.2 RACK MOUNTING

First, separate both slide sections into two pieces by pulling the innermost
piece out past the mounting flanges. It is necessary to push in the release
buttons to accomplish this.

The two larger slide sections (with flange) should be mounted onto the cabinet's
vertical rails. In order to fit the HD-11 into a 10-1/2" section, screw the
bottom slot of the flange into the 4th hole above the top edge of any equip-
ment lower in the rack. (The tapped retainer plate is supplied for cabinets
without tapped holes.)

The two right-angle brackets are for attaching the rear of the slides to the
cabinet. First, mount these brackets in the same way that the front flanges
of the slides were mounted. Use two 10-32 screws to mount the brackets onto
the vertical rails. If you have the three section slides, pull out the two
middle sections from the just-installed slides, until they lock in place.

Mount the rear slide section to these brackets, again using 10-32 screws.
Mount the inside slide section to the HD-11 cabinet, again using 10-32
screws and lockwashers. The spring buttons should be in the back of the
HD-11 cabinet and facing outward.

|WARNING|

          THE HD-11 IS QUITE HEAVY AND COULD
          TOPPLE THE CABINET WHEN IT IS IN ITS
          EXTENDED POSITION.
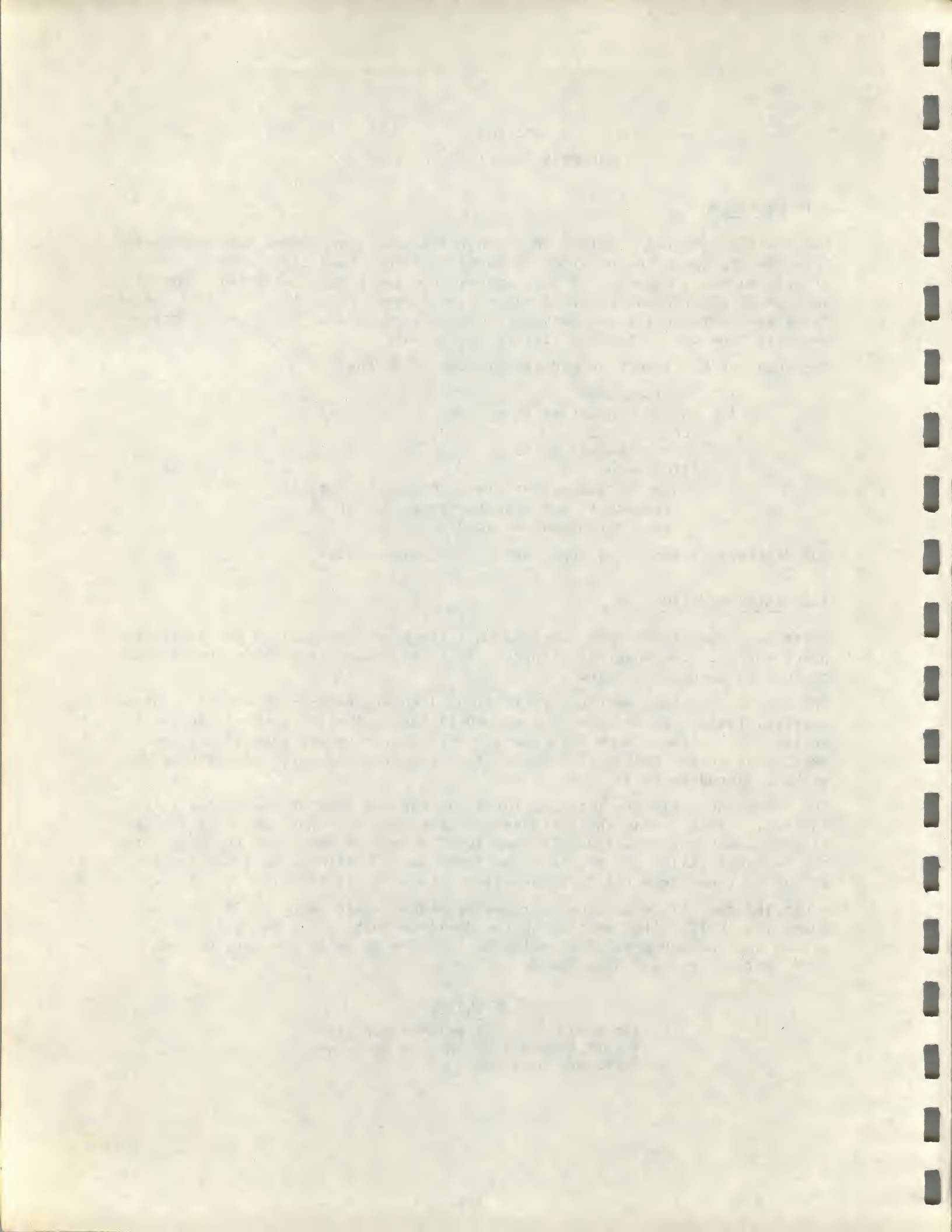
To slide the HD-11 into the cabinet, carefully lift the HD-11 and mate the slide sections. After pushing a short distance, the safety catch must be pressed in to allow the unit to travel further. Again, the safety catch must be pressed in to slide the HD-11 completely into the cabinet. Once properly installed into a cabinet on its safety-lock slides, the HD-11 can be easily pulled out part-way for most service or inspection access. To fully remove the device from its cabinet enclosure, the spring-loaded safety buttons or stops on each slide must be depressed until they pass the mating holes contained in the other portion of the slide.

2.3 TABLE MOUNTING

There are four threaded inserts on the bottom of the HD-11 cabinet for those users who may wish to use a table-mounted HD-11. A set of four machine screws and four rubber feet will be supplied to any customer on request.

2.4 HC-210 INTERFACE AND INSTALLATION

The HD-210 should next be configured, if necessary, to the user's needs.

The HC-210 is shipped with the following jumper selections:

Device addresses:	774400 - 774406
Vector interrupt address:	160
Bootstrap:	Enabled
Priority level (LSI-11/23 only):	4 (LSI-11/2 level)

The user may make any reconfiguration in accordance with Figure 2-1 and the chart following.

In general, it is not necessary to make any changes in the device address or interrupt vectors unless there is more than one RL01-type disk controller on the system.

The user should be warned that earlier versions of RT-11 were supplied with the RL01 vector set at 330 instead of 160. This has since been corrected. We suggest the user patch RT-11 in accordance with DEC's software update releases rather than change the HC-210's interrupt vector address.

The bootstrap on the HC-210 must be disabled if there is another bootstrap card in the system.

Z15

J4 J5
J6 J7
J8 J9
J10 J11
J12 J13

J3
J2

J1
CRYSTAL

J21
J20
J19
J18
Z27   J17
J16
J15
J14

Z40
20
J22 J23 J24 J25 J26 J27 J28 J29 J30 J31

FIGURE 2-1

Function	Jumper	Installation
Factory only	J1	always installed
Bootstrap disable	J2	install for boot disable
Bootstrap enable	J3	install for boot enable
Interrupt Bit 7	J15	install for 0
Interrupt Bit 6	J17	install for 0
Interrupt Bit 5	J19	install for 0
Interrupt Bit 4	J21	install for 0
Interrupt Bit 3	J20	install for 0
Interrupt Bit 2	J18	install for 0
Interrupt Bit 1	J16	always installed
Interrupt Bit 0	J14	always installed
Address Bit 12	J22	install for 0
Address Bit 11	J31	install for 0
Address Bit 10	J23	install for 0
Address Bit 9	J24	install for 0
Address Bit 8	J29	install for 0
Address Bit 7	J30	install for 0
Address Bit 6	J26	install for 0
Address Bit 5	J25	install for 0
Address Bit 4	J27	install for 0
Address Bit 3	J28	install for 0
Priority Level 4		install: J4,J6,J8,J10,J12 open: J5,J7,J9,J11,J13
Priority Level 5:		install: J4,J6,J8,J11,J13 open: J5,J7,J9,J10,J12
Priority Level 6:		install: J5,J7,J9,J10,J12 open: J4,J6,J8,J11,J13
Priority Level 7:		install: J5,J7,J9,J11,J13 open: J4,J6,J8,J10,J12

2.4.1 HC-210 MODULE PLACEMENT

The user must next select a backplane position for the HC-210 module. It
occupies a full quad slot and for that reason it may be necessary to change
the position of some cards already in the system. No empty slot (dual or
quad) is allowed between the processor (usually in the first slot) and a
DMA peripheral. This is because two signal lines which handle interrupt
and DMA grants are broken by each slot on the backplane. This gives devices
physically nearest the processor the highest interrupt priority. This system
prohibits empty backplane slots between the processor and an interrupt-driven
device interface. The backplane-determined priority levels are shown in
Figure 2-2 for both four- and eight-slot backplanes.

```
 ┌──────────────────────────────────────────────────────┬──────────┐
 │ KD11-HA >-----------1-+-------------\          │    2     │
 ├──────────────────────────────────────────────────────┼──────────┤
 │     /-----------4-+---------<---'          │    3     │
 ├──────────────────────────────────────────────────────┼──────────┤
 │     \--->-------5-+-------------\          │    6     │
 ├──────────────────────────────────────────────────────┼──────────┤
 │     /-----------8-+---------<---'          │    7     │___| 4-slot
 ├──────────────────────────────────────────────────────┼──────────┤
 │     \--->-------9-+-------------\          │   10     │
 ├──────────────────────────────────────────────────────┼──────────┤
 │     /----------12-+---------<---'          │   11     │
 ├──────────────────────────────────────────────────────┼──────────┤
 │     \--->------13-+-------------\          │   14     │
 ├──────────────────────────────────────────────────────┼──────────┤
 │     <----------16-+---------<---'          │   15     │___| 8-slot
 └──────────────────────────────────────────────────────┴──────────┘
```
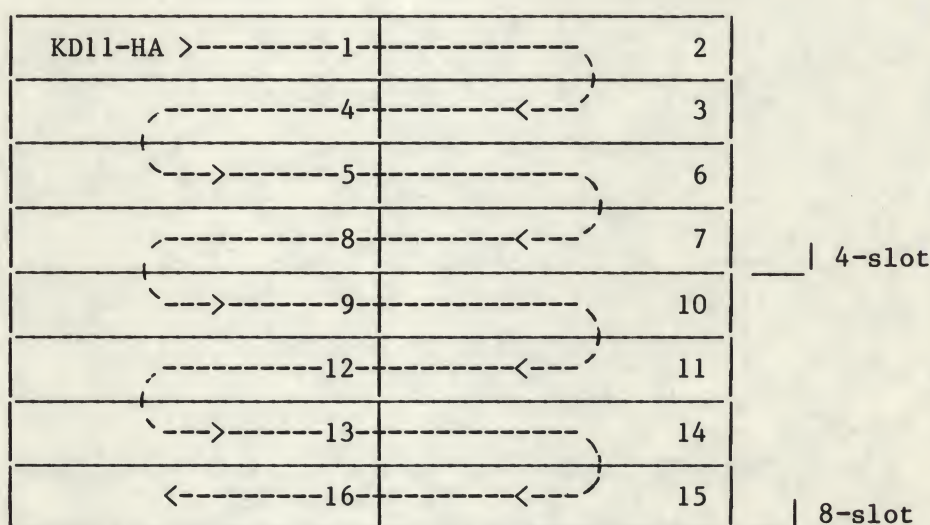
PRIORITY SEQUENCE MAP

FIGURE 2-2

DEC nine-slot backplanes such as those supplied in the 11/03-L are only wired
for the Q-bus in the A and B slots. For that reason the HC-210 may occupy
any slot in the backplane as long as there are no vacancies between it and
the processor in the A/B slot. Vacancies in the C/D slots are irrelevant.

In general, devices requiring time-critical interrupt service, such as high-
speed modems which will lose data if it is not processed before the next
character is received, should be placed closer to the CPU than devices which
operate with low speeds or buffers. Memory and other devices which never
require interrupt service may be placed anywhere.

If the user is using an 11/23, the interrupt priority levels may be used
to determine the priority rather than distance from the processor. Distance
from the processor is still used to determine priority within a given level.

There are four levels of priority: 4, 5, 6 and 7, with 7 being the highest
priority. Devices built without 11/23 priority levels are still compatible
with the system and respond at priority level 4. DEC suggests priority
level 5 for the RL01, but any level of priority should be satisfactory for
the HD-11.

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2.4.2 MODULE INSERTION

Insert the HC-210 along the card edge guides. Apply force to the handles
when card edges are lined up with backplane slots. Considerable force may
be required to seat the card; make sure the card fingers and corresponding
backplane connectors are properly aligned. Never apply enough force to
distort or bend the card's basic structure.

2.5 CABLE INSTALLATION

The line cord may be installed by insertion into the oval hole in the rear
of the HD-11 chassis. The cord thus mates directly with a line filter.
The other end of the line cord is best connected to a processor switched
AC source so that the HD-11 powers up and down with the computer. The HD-11
controller does have its own power-up circuitry so this is not essential.

The HD-11 is shipped with a 50-conductor ribbon cable exiting from a slot
in the rear of the chassis and folded and taped to the side of the chassis.
This cable should be unfolded and routed to the processor where it attaches
to the HC-210 interface card. The cable should now be inserted as shown
in Figure 2-3.

2.6 PACKING

If for any reason it is necessary to ship the HD-11, the head should be moved
in to the inner unused cylinders of the disk. This is most easily accomplished
by the following software procedure. Using ODT, enter octal 16 into location
774400 (or the new CSR location if you have changed it). Immediately turn the
power-off on the disk drive so that the head will not be moved by a power reset.
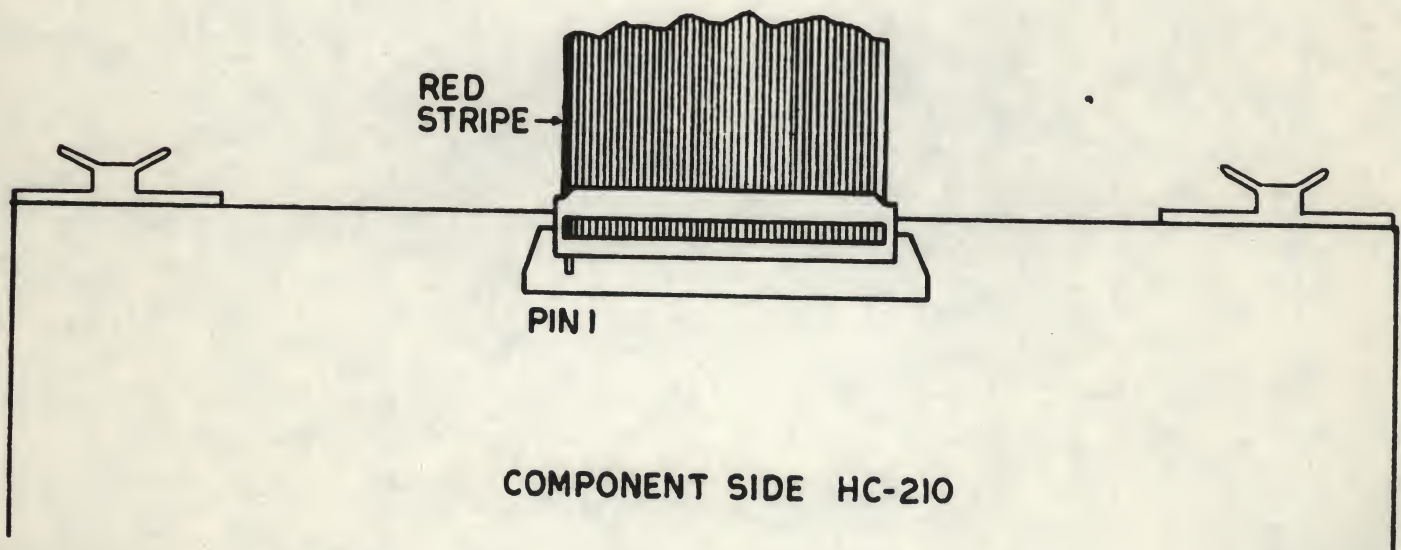
RED
STRIPE→

PIN I

COMPONENT SIDE HC-210

FIGURE 2-3

2.7 INITIAL CHECKOUT

AC power may now be turned on. The operator must wait approximately two minutes for the disk to get up to speed. When the drive is up to speed, the READY light on the HD-11 will come on. No functions on the drive will operate until this occurs.

After READY is on, an INIT should be sent to the HD-11. This is accomplished by cycling the processor's DC power switch, or typing OG to ODT with the halt switch down, or pressing the INIT or BOOT switch available on some processors. Using ODT, register 774400 should be examined (type 774400/). The contents of this register should be 201. If it is not, recheck the cabling, the seating of the HC-210 card, and other installation procedures.

CRDS has allotted an unused cylinder on the disk to store some utility programs for use with the HD-11. The HD-11 is supplied with these programs which include a disk diagnostic, a tape-to-disk and disk-to-tape transfer program, a tape diagnostic, a Track Reassignment File update program, and a program to format the disk drive. We suggest that the HD-11 disk diagnostic be run at this time.

The easiest way to load the diagnostic is to use the bootstrap on the HC-210 card. Start the bootstrap routine by starting the processor at location 773000. This is done automatically if the processor is strapped for power-up mode 2. Otherwise, type 773000G to ODT.

The bootstrap program will type an asterisk. Type in SP (for special programs), followed by a carriage return. This will cause the bootstrap program to load the special programs off the disk's hidden track. The diagnostic program may then be selected from a menu. The user should refer to Section 5 for information on using the diagnostic.
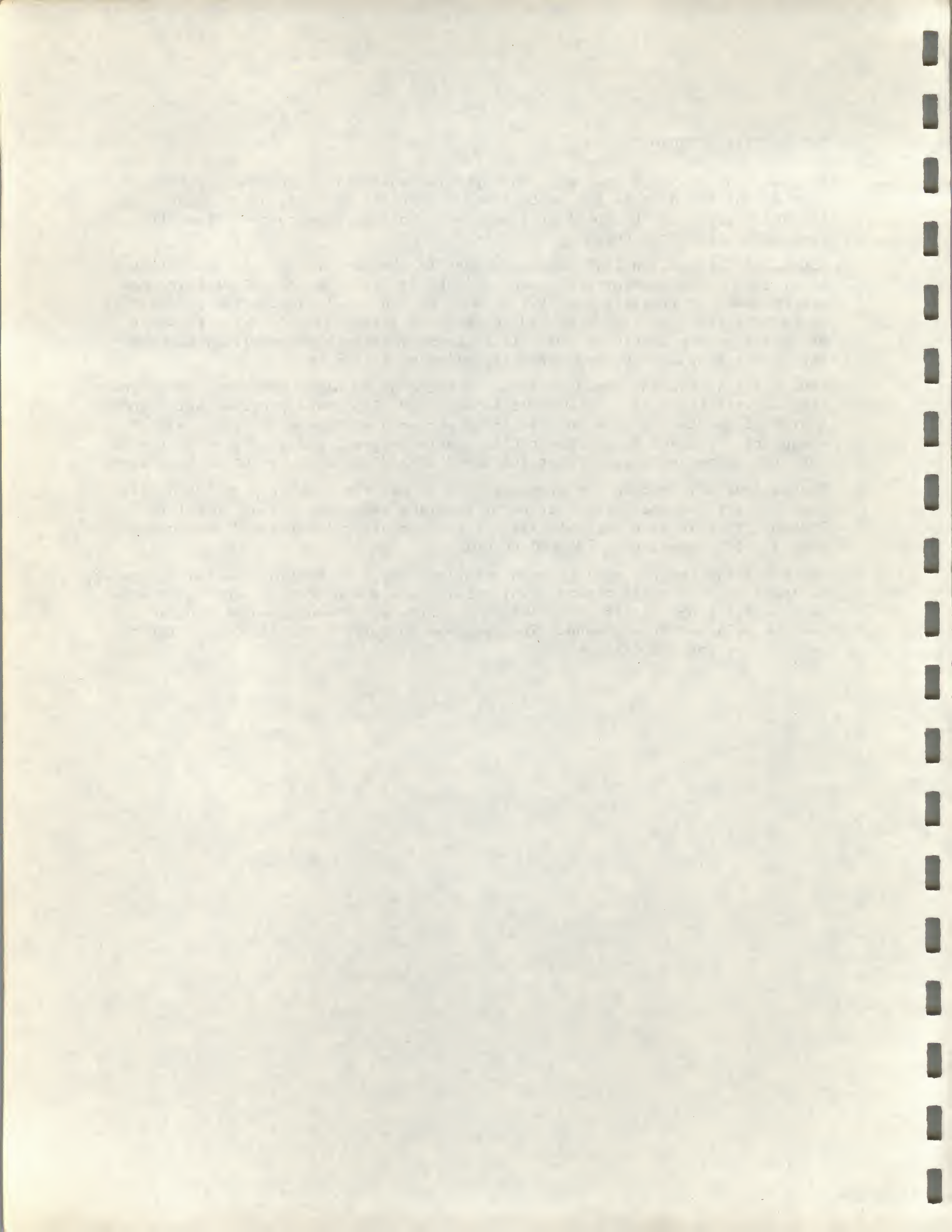
Section 3
OPERATING INSTRUCTIONS

3.1 STORAGE FORMAT

The HD-11 is a 24.8 megabyte (formatted) disk that has been made to appear as four 5.2 megabyte (formatted) disks in order to remain software-compatible with DEC's RL01. A chart comparing the <u>physical</u> storage format of the HD-11 and the <u>logical</u> storage format of the HD-11 and RL01 appears below.

	Physical HD-11	Logical HD-11 or RL01
number of cylinders	202	256
number of surfaces	4	2
number of heads	8	2
number of tracks	1616	512
number of sectors per track	60	40
number of bytes per sector	256	256
number of bytes per drive	24,821,760	5,242,880

To match the RL01's logical storage format, the HD-11 was mapped into four pseudo-RL01's as shown below:

1	HD-11 track	(60 sectors)	=	1.5 RL01 tracks (40 sectors)
1	HD-11 cylinder	(480 sectors)	=	6 RL01 cylinders (80 sectors)
43	HD-11 cylinders		=	1 RL01 platter or 256 cylinders

A schematic diagram of the mapping algorithm is shown in Figure 3-1. Notice that the RL01 pseudo-unit contains far fewer tracks than a real RL01 unit (43 as compared to 256 tracks). This causes the average seek time of an HD-11 to be quite fast when limited to seeks within the bounds of one RL01 pseudo-unit. In fact, for up to six consecutive tracks, the HD-11 requires no seeking and does not move its head even though the RL01 software driver issues a seek command.

Ironically, the head positioning mechanism on the RL01 is a voice coil and is faster than the HD-11's band-driven mechanism, yet nevertheless the HD-11 is faster when limiting its seeks to one unit's range. This results from a greater bit density (factor of 1.5) and a larger number of heads (factor of 4).

3.2 WRITE-PROTECT SWITCHES

There are four write-protect switches on the front panel of the HD-11 labelled 0 through 3. This refers to the four RL01 pseudo-units DL0, DL1, DL2, and DL3. These alternate-action switches will light up in the IN position indicating that RL01 unit is write-protected. The RL01 unit is write enabled when the switch is in the OUT position and the light is off.

APPROX. 43 TRACKS PER ANNULAR RING

UNIT Ø
UNIT 1
UNIT 2
UNIT 3

UNIT 0
UNIT 1
UNIT 2

UNIT 3

2 HEADS
PER SURFACE

HEAD ACTUATOR ASSEMBLY

FIGURE 3-1

These switches provide a convenient means of write-protecting a section of
the physical disk. It may be used to protect one user's area from another
user's area if the users are working on separate units at different times.
It may also be used as a quick backup technique protecting against a pro-
grammer's error deleting important files.

It is important to remember that these switches are read only by the microcode
and therefore do not protect against some hardware failures. The switches
are not wired directly into the disk's write current circuitry because write
protection is dependent upon the segment of the disk being accessed. The
write protect feature is therefore only as good as the integrity of the
microcode hardware.

Remember not to write-protect the disk section which is your system device.
Writes occur automatically by the system such as swapping out the USR on the
RT-11 operating system. Write protection may, in that case, cause the system
to crash.

3.3 READY INDICATOR AND CIRCUIT BREAKER

The leftmost indicator switch is an indicator only that comes on when the
disk is up to speed. The HD-11 detects that the drive is up to speed by means
of a timing track on the disk itself. It takes approximately two minutes
after AC power is applied for the READY indicator to come on.

Because the media is not interchangeable, there is no reason to turn the
disk on and off except when shutting down the entire system. The only means
provided to do this is a switch located at the rear of the HD-11.

3.4 HD-11 OPERATION UNDER EXISTING SOFTWARE

The HD-11 will run under RT-11 or RSX-11 and should work with any other system
that has a handler for RL01-type disk drives.

If RT-11 is used, version 3B or a later revision level must be used. Earlier
versions do not contain the RL01 handler. Using the HD-11 is then the same
as using four RL01 drives. A SYSGEN must be done on RT-11 in order to allow
access to all four pseudo-drives. The user must then remember to do the INIT
function on each unit, just like all other disk peripherals, to initialize the
directory blocks.

If RSX-11 is used, version 3.2 or a later revision must be used. Earlier
versions do not contain the RL01 handler.

3.5 GETTING STARTED WITH THE HD-11

It is advisable that for most systems some form of removable media be avail-
able in addition to the HD-11 disk. This is important to allow backup, the
input of diagnostics, and exchange with other systems. CRDS provides a tape
option for the HD-11 as well as fully DEC-compatible floppy disk drives. There
are many other removable media peripherals also available. If a user has more
than one system, he may need only one such peripheral and switch it between
systems when it is is needed.

If floppy disk, RK05, or other disk drive is available on the system, getting
started is quite simple. If the operating system is running on the other
peripheral and it includes the RL01 handler, it may easily be transferred to
the HD-11. The user may use INIT to initialize the RL01 directories and then
use PIP in order to transfer files.

If the HD-11 tape option is the only access to the system, CRDS provides a
service of transferring DEC distribution media to tape. If you purchase your
software on RL01 platters or on single or double density floppy disks (RX01,
RX02), CRDS can transfer this to tape. The instructions on tape-to-disk
transfers can be found in Section 5.2.6.

3.6 BAD TRACK REASSIGNMENT

3.6.1 PURPOSE AND OPERATION

The media used in the HD-11 (SA4008) may have up to 96 tracks with bad spots.
The controller has been given the ability to automatically skip bad parts of
the disk, making the emulated RL01 images appear perfect. This is possible
because the capacity of the media (24.8 MB) exceeds that of the four RL01
images (21 MB).

An SA4008 track has 60 sectors, while an RL01 track has 40; thus three RL01
tracks exactly fit into two SA4008 tracks. To simplify the controller, SA4008
tracks are reassigned in pairs. Each pair of SA4008 tracks is called a SEGMENT.

The list of bad SEGMENTS, called the Track Reassignment File, is written by
CRDS on the "special area" of the disk (see Section 4.3). The controller reads
this information from the disk and stores it in RAM on the controller card each
time it receives a BUS RESET. A BUS RESET will occur when either power is
turned on, a "RESET" instruction is executed by the CPU, or the INIT switch
is depressed. If the controller cannot read the Track Reassignment File on
the disk, it will not perform any commands and will not assert "controller
ready" after being given the first command. Putting in the "format jumper"
(see Section 3.8) will allow operation in this condition, but the controller's
copy of the Track Reassignment list will be undefined and the controller should
not be used for anything other than rewriting the Track Reassignment File on the
disk. This should be done using the support software provided by CRDS as des-
cribed in Section 5.2.3.

Once initialized, every READ DATA or WRITE DATA command will cause the controller
to convert the RL01 track address to an SA4008 track address. The controller will
then examine the Track Reassignment list in its RAM. For every bad SEGMENT that
preceeds the requested track, it will add 2 to the requested track, thus bypassing
that bad part of the disk. This will continue until the next bad SEGMENT in the
list is beyond the updated value for the requested track. The controller will use
the final updated value as the actual location on the disk. Because bad SEGMENTS
are simply skipped, little, if any, degradation in performance is encountered.

3.6.2 TRACK REASSIGNMENT FILE FORMAT

The Track Reassignment File is stored in the last two sectors of the "special area"
of the disk (see Section 4.3). The first of the sectors is used only by the HD-11
support software to maintain a list of bad physical tracks on the disk. The list
contains no redundancies, is sorted lowest track first, and is terminated by a word
containing all ones (177777). The rest of the sector is also filled with words con-
taining all ones. This information can be displayed and/or modified with the HD-11
support software (see Section 5.2.3).

The second of the two sectors (the last sector of the special area) is the sector
actually used by the disk controller. The format of this sector is such that it
is easily used by the controller. When reading this description one should refer
to Figure 3-2. The list in this sector is a list of bad SEGMENTS (as opposed to
tracks). The information appears as a sequence of bytes with only the low four
bits of each byte being used. Each entry is made up of ten bits identifying a
unique bad SEGMENT of the disk. The entries are stored in their two's complement
form. The list is terminated by an entry of zero.

Because each entry is ten bits long and only four bits of each byte are used,
every pair of entries uses up five bytes with the low four bits of one byte shared
by two entries. In the picture, bits of each entry are numbered 0 through 9 as
the least significant bit through most significant bit, respectively. The first,
third, fifth, ... etc. entries are stored in the "A" form while the second, fourth,
sixth, ... etc. entries are stored in the "B" form. The remainder of the sector
is all zeroes.

byte 0	X X X X	9_A 8_A 7_A 6_A
byte 1	X X X X	5_A 4_A 3_A 2_A
byte 2	X X X X	1_B 0_B 1_A 0_A
byte 3	X X X X	9_B 8_B 7_B 6_B
byte 4	X X X X	5_B 4_B 3_B 2_B
byte 5	X X X X	
byte 6		

Figure 3-2

3.7 SPECIAL HD-11 FUNCTIONS

The HD-11 is supplied with several programs written at CRDS that provide
several useful functions. These programs include:

(1) a formatting routine for the HD-11,

(2) a data reliability disk diagnostic,

(3) a program to read and modify the Track Reassignment File on the
     special section of the disk

(4) the disk-to-tape and tape-to-disk routines for the tape option,

(5) tape diagnostic, and

(6) a program to transfer the special programs from one media to another.

These programs are stored on the "special area" of the HD-11 (see Section 4.3).

These programs may be booted by using the CRDS-supplied bootstrap on the
HC-210 card. Typing the command SP (for special programs) to the prompt
followed by a carriage return will cause the bootstrap card to load the
special functions programs. The user may then select the particular special
function program desired by answering a question posed by the special functions
program.

If the HD-11 bootstrap option is not used, a bootstrap must be entered via ODT
if the user wishes to do an "SP Boot".

First, load the HD-11 registers as follows:

1. Load   0   into 774402

2. Load 100000   into 774404

3. Load 166000   into 774406

4. Load   4   into 774400

(If you have changed the device addresses (Section 2.4), these addresses will
be different.)

Now, 774400 should have a 205 in it, and location 0 should have a 240 in it.
If so, next load the LSI-11 registers as follows:

1. Load   340   into R0

2. Load 174400   into R1 (or the new address, if you changed it)

3. Load   340   into RS

4. Load   0   into R7

Then, type "P" to start execution at location 0.

3.8 THE FORMAT JUMPER

The format jumper on the HC-300 card (Figure 3-3) changes the operation of the system in several ways. When it is not installed, formatting of the disk and writing to the special area are disabled, and the Track Reassignment File (see Section 3.6) is read from the disk on a bus reset. When it is installed, writing the special area and formatting are enabled; and the Track Reassignment File is not read from the disk on a bus reset.

All bus resets destroy the track reassignment information stored in RAM on the controller card. However, if the format jumper is out, the Track Reassignment File is immediately read back into the RAM. If the jumper is in, this does not happen and the track reassignment information remains invalid in the RAM. If an area of the disk other than the "special area" is then referenced, track reassignment will be done using the invalid information, causing references to the wrong parts of the disk. Therefore, no area other than the special area should ever be referenced while the format jumper is installed. Also, a bus reset should be done after the format jumper is removed. (If the jumper is installed and removed according to instructions given by the HD-11 support software, this reset is done by the software.)

Three special functions (formatting, modifying the Track Reassignment File, and transferring the special programs to the "special area") require that the format jumper be installed on the HC-300 controller card. To do this, the lid of the HD-11 chassis must be removed by rotating counter-clockwise, one quarter turn, the six screws that hold it and lifting the lid to allow access to the HC-300 card. Figure 3-3 shows the location of the format jumper on the HC-300 card. It is shipped installed on one of a pair of pins. The programs for the special functions will request, at the appropriate time, that the format jumper be installed, at which time it should be placed on both pins. At the completion of the function, the program will request that the jumper be removed, at which time it should be placed back on one pin. Except for these special functions, the HD-11 must never be operated with the format jumper installed. Otherwise, some of the data on the disk may be unreadable, and new data may be written in the wrong places.

HC-300   CARD

INTERFACE CONNECTOR

FORMAT JUMPER

TAPE CONNECTOR

DISK CONNECTOR
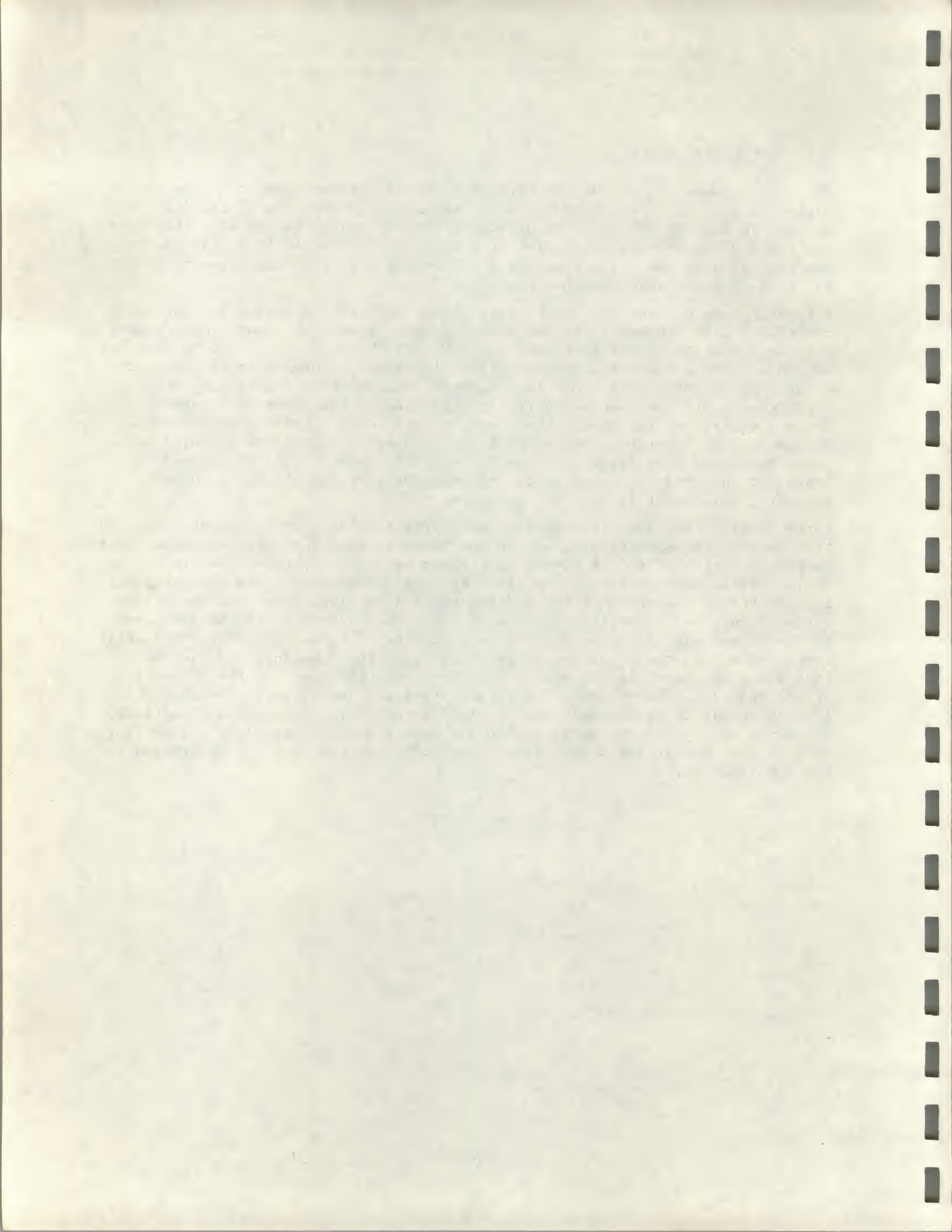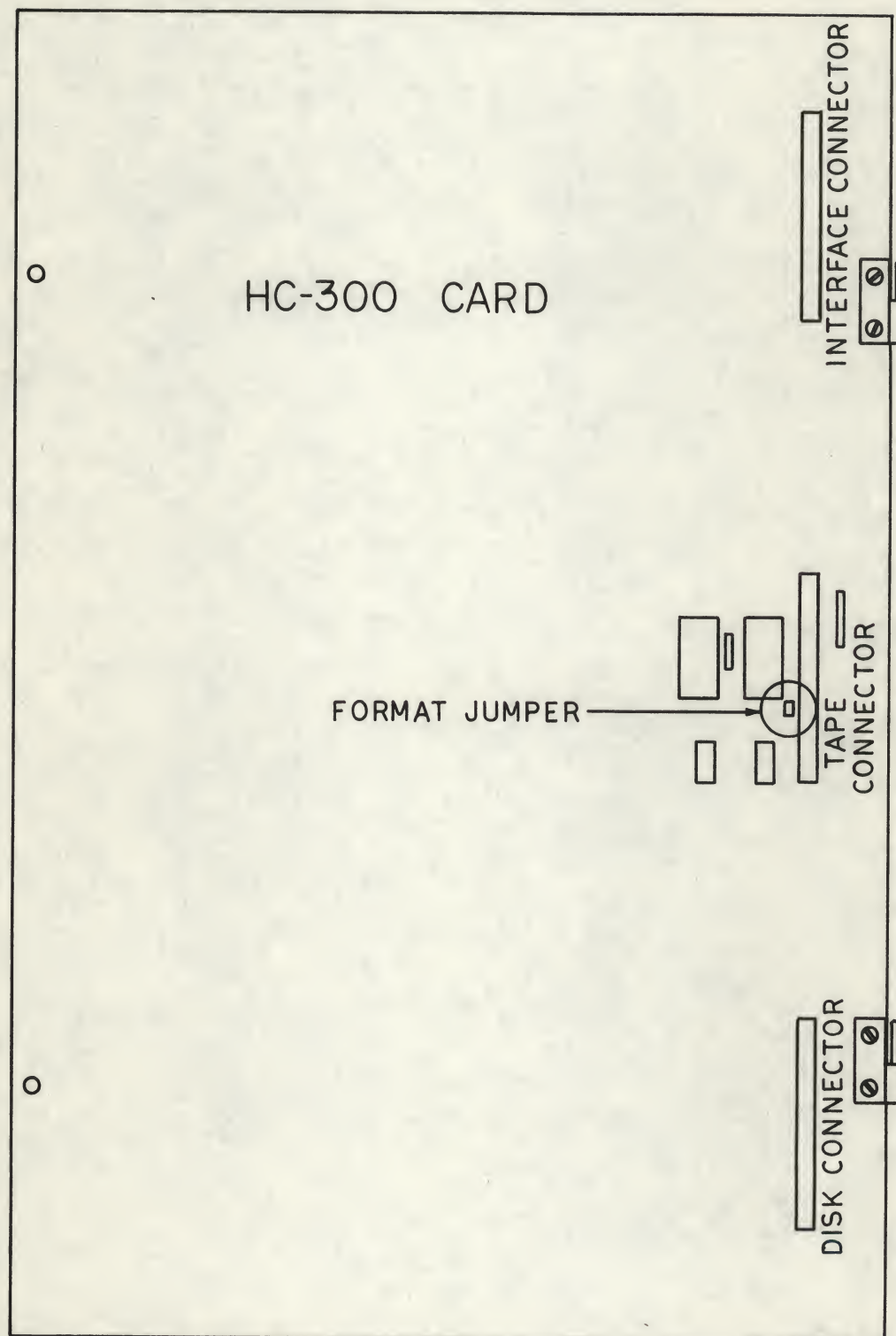
FIGURE 3-3

3.9 MAINTENANCE

The disk drive, being sealed, requires no preventative maintenance. The tape drive, however, since it is not sealed, does require periodic maintenance. To gain access to the tape drive, the lid of the HD-11 must be removed by turning counter-clockwise the six quarter-turn fasteners that hold it, and then just lifting the lid off the box.

The magnetic head should be cleaned daily if the tape drive is in regular use. Dirty heads may cause data dropouts during read and write operations. Use a non-residue, non-corrosive cleaning agent, such as duPont Freon TF or isopropyl alcohol, and a cotton swab to clean the head assembly. Be sure to wipe up any excess and allow the heads to dry prior to operating the drive.

| CAUTION |

Spray type head cleaners are not recommended because overspray may contaminate the motor bearings. This will result in permanent head damage.

(Refer to Figure 3-4.) The tape cleaner removes loose tape oxide and other foreign material from the tape before it contacts the head. This foreign material accumulates in and around the tape cleaner and must be removed to ensure that the tape cleaner will continue to work effectively. The tape cleaner should be cleaned on the same schedule as the head.

To clean, insert a folded sheet of paper in the bottom of the cleaning slot of the cleaner. Slide the paper up, lifting the foreign material from the cleaner. Compressed air or a soft brush may be used to remove the foreign material from the area around the tape cleaner and head assembly. Alternately, the tape cleaner can be cleaned using the same materials used to clean the magnetic head.

| CAUTION |

Do not use hard objects to clean the tape cleaner! If the tape cleaner should become chipped, it could scratch the tape surface, resulting in lost data and/or permanent tape damage.

The drive capstan is composed of hard polyurethane and must be cleaned after foreign material has built up. Clean, using isopropyl alcohol and a cotton swab. The cleaning schedule should be the same as for the head.

| CAUTION |

Be very careful not to permit cleaning solvent to contaminate the drive motor bearings.

MOTOR CAPSTAN

DRIVE MOTOR

HEAD ASSY.

TAPE CLEANER
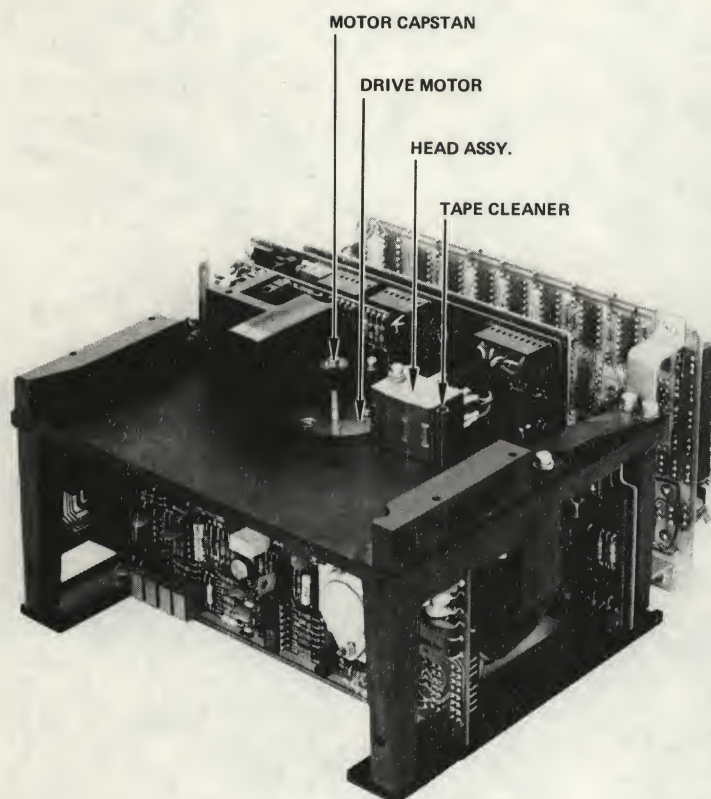
LOCATION OF PARTS REQUIRING PERIODIC CLEANING

FIGURE 3-4

To prevent possible overheating, dust and dirt should be removed from the heat sink and drive assembly components as required. The time period between cleanings will vary widely, depending upon the operating environment. Use a soft brush and/or compressed air for cleaning. The sensor holes should be cleaned in the same manner.

4.1 HD-11 REGISTERS

The HD-11 has four registers addressable in the top 4K of the LSI-11's address
space. These four registers are equivalent to the four RL01 registers speci-
fied by DEC. There are some minor differences between the register specifica-
tions of the HD-11 and RL01 arising from physical differences between the
two drives. Most of these differences amount to the HD-11 returning a 0
instead of a drive status bit irrelevant to the HD-11. In this way, complete
software compatibility is maintained.

All four registers are both readable and writeable although the multipurpose
register has a different meaning when being read than when it is written.
The bus address register resides on the HC-210 interface card where it is used
for DMA operations. The other three registers are stored on the HC-300 con-
troller card. The multipurpose register, when used as a word count register,
is also written into a storage element on the HC-210 card so the end of a
DMA can be determined. The HC-210 card transmits and receives 16 bits of
data to and from the HC-300 card during reads and writes of the three HC-300
based registers.

The functions of the four registers are listed below.

Control and Status Register	774400	Provides major status signals and accepts commands.
Bus Address Register	774402	Address of memory location accessed during a DMA operation.
Disk Address Register	774404	Used to specify sector and track addresses.
Multipurpose Register	774406	Used as a word count register, as a buffer for header information, and to convey status information.

4.1.1 CONTROL AND STATUS REGISTER (CSR)

A bit map of the CSR is shown below. The second line of bit descriptions are used when a tape command has been executed and they are described in Section 4.1.1.1.

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
ERR	DE	NXM	HNF	CRC	OPI	US1	US0	CRDY	INT ENB	A17	A16	F2	F1	F0	DRDY
	EC3	EC2	EC1	CRC	EWS	TS1	TS0								Read Only

After a bus init, the CSR should have bit 7 (Controller Ready) set to 1 and bit 0 (Drive Ready) set to 1. All other bits should be set to 0. A command is initiated by clearing bit 7 (CRDY). After a command is completed, either normally or as the result of an error, bit 7 (Controller Ready) is set back to 1.

A description of each of the CSR bits follows.

Bit	Name	Function
0	Drive Ready (DRDY)	This bit is always set to 1.
1-3	Function Code	These bits determine which of the following eight commands is executed when a command is initiated.

Octal	F2	F1	F0	Command
0	0	0	0	NOP
1	0	0	1	NOP
2	0	1	0	Get Status
3	0	1	1	Seek
4	1	0	0	Read Header
5	1	0	1	Write Data
6	1	1	0	Read Data
7	1	1	1	NOP

Bit	Name	Function
4,5	Bus Address Extension Bits 16 & 17	These two extra bits are needed to address up to 128K words of memory.
6	Interrupt Enable	If this bit is set, an interrupt will be generated at the completion of a command.
7	Controller Ready (CRDY)	This bit is cleared in order to initiate the command specified by bits 1-3 of the CSR. This bit is set by the controller at the completion of a command.

Bit	Name	Function
8-9	Unit Select Bits	These bits determine which RL01 pseudo-drive the HD-11 accesses.

US1(9)	US0(8)	Unit
0	0	0
0	1	1
1	0	2
1	1	3

Bit	Name	Function
10	Operation Incomplete OPI	This bit is set to one if there is a Header Not Found error or if an inconsistent header is read during a Read Data or Write Data command (see bits 11 and 12). It is also set if a Get Status command is given with bit 1 of the DAR set and bit 2 of the DAR cleared.
11	CRC	If the OPI bit (bit 10) is cleared and this bit is set, a CRC error occurred on a data field. If OPI is set and this bit is set, a discrepancy occurred in reading redundant words of the header. Note: the HD-11 uses redundancy rather than a CRC for checking headers.
12	Header Not Found (HNF)	If the OPI bit (bit 10) is set and this bit is set, a sector header could not be found on a read or write operation. Note: this bit is used for data late errors on the RL01 but these errors cannot occur on the HD-11 because it contains a full sector buffer.
13	Non-existent Memory (NXM)	When this bit is set, no reply (BRPLY) was received on a DMA cycle within approximately 15 microseconds.
14	Drive Error (DE)	This bit is set when the drive detects an error during writing. This includes: (a) Write gate signal not coincident with write current (b) Multiple heads selected (c) Drive was not ready (d) Read gate active
15	Composite Error (ERR)	When this bit is set, it indicates that one or more of the errors bits (CSR, bits 10-14) is set.

4.1.1.1 CSR HIGH BYTE FOR TAPE COMMANDS

A command is given to the tape drive by doing a Get Status command with the Disk Address register set as specified in Section 4.1.3.3. The low order byte of the Control and Status register has its usual format, but the high order byte is as follows:

Bit

15	Composite Error Bit
14	Error Code 3
13	Error Code 2
12	Error Code 1

EC3 14	EC2 13	EC1 12	
0	0	0	Not used
0	0	1	Drive not ready (no cartridge, no power, sensor lamp out)
0	1	0	Not used
0	1	1	Cartridge write protected (only returned on write command)
1	0	0	Non-existent memory
1	0	1	DMA error (DMA took too long)
1	1	0	Missing data (may be dropout)
1	1	1	Not used

11	CRC Error (can occur on read or write)
10	Early Warning sensed (36" left)
9	Track Select 1 ⎱ used only for
8	Track Select 0 ⎰ Select Track function

Bits 8 and 9 are specified by the software; bits 10-15 are returned after a command is completed.
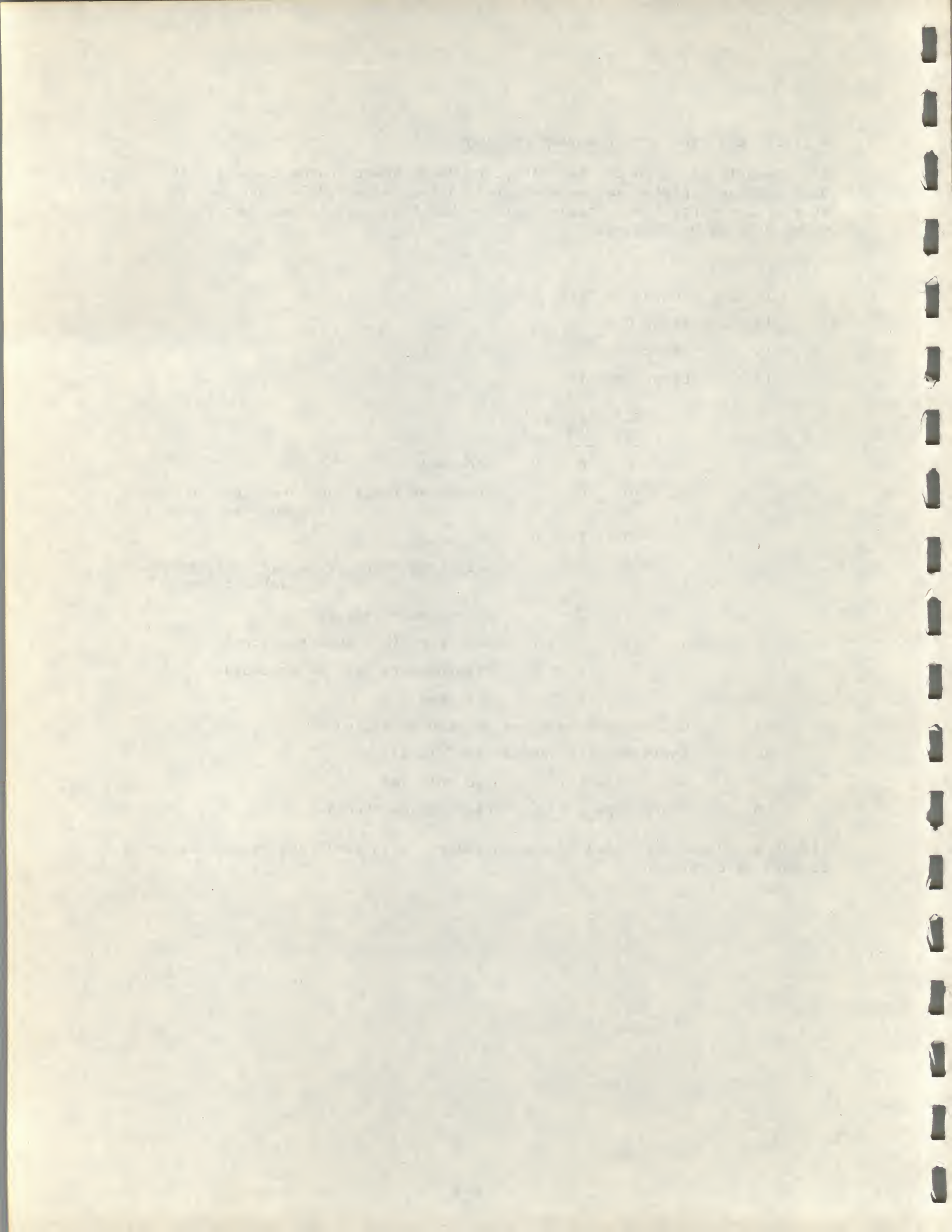
4.1.2 BUS ADDRESS REGISTER (774402)

This 16-bit register contains the memory location being accessed during a DMA operation. It should be set to the first address of the I/O buffer before initiating a read or write command.

Bit 0 of this buffer must always be set to 0. No odd addresses are allowed.

Bits 4 and 5 of the CSR are an expansion of this register for address bits 16 and 17, respectively. The Bus Address Register overflows into these two bits.

4.1.3 DISK ADDRESS REGISTER (774404)

This 16-bit read/write register has three different meanings depending upon the command being executed. It is used during

    (1) seek commands,
    (2) read and write commands, and
    (3) during get status commands.

It is cleared to 0 by a bus init.

4.1.3.1 DISK ADDRESS REGISTER ON SEEK COMMANDS

This register provides the track difference, the seek direction, and head selection for seek commands as shown below.

```
  15   14   13   12   11   10    9    8    7    6    5    4    3    2    1    0
 ---------------------------------------------------------------------------------
|  X  |<--------TRACK  DIFFERENCE-------------->|  X  |  X  | HS  |  X  | DIR |  X  |  X  |
 ---------------------------------------------------------------------------------
```

Bit	Name	Function
2	DIR	Determines whether the track difference is added (1) or subtracted (0) to the present track address to determine the new track address.
4	HS	Determines head to be selected .
7-14	TRACK DIFFERENCE	Difference between new track address and old track address.
	X	All other bits are unused.
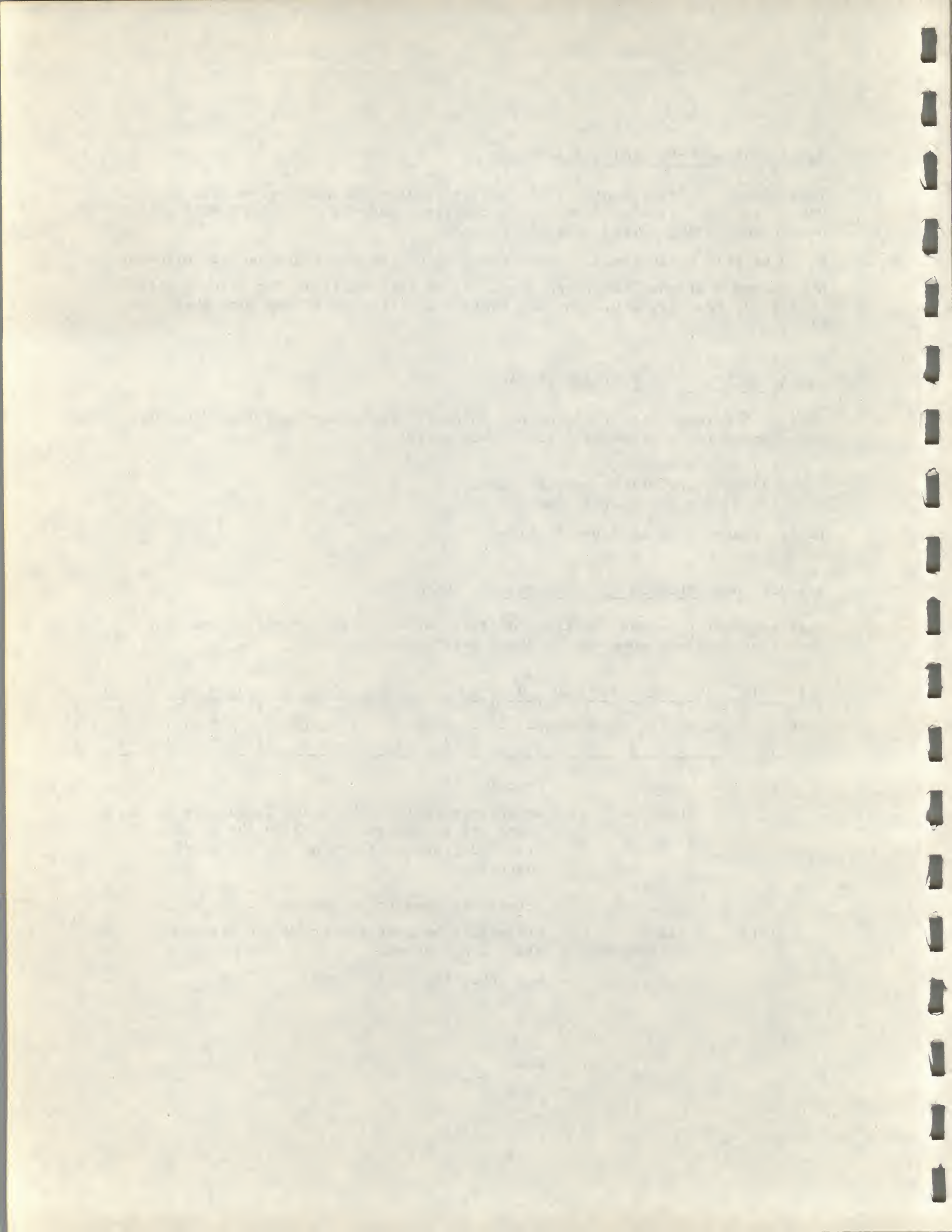
4.1.3.2 DISK ADDRESS REGISTER DURING READ/WRITE COMMANDS

This register is used to convey the sector, head, and track address on which
a read or write is to be performed. After each consecutive sector transfer,
the sector part of this register is incremented.

```
  15    14    13    12    11    10    9     8     7     6     5     4     3     2     1     0
 _____
|     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
|  X  |<-------TRACK ADDRESS---------------->|  HS |<-------SECTOR ADDRESS------>|
|_____|_____|_____|_____|_____|_____|_____|_____|_____|_____|_____|_____|_____|_____|_____|_____|
```

Bit	Name	Function
0-5	Sector Address	One of 40 sectors.
6	Head Select	One of two heads.
7-14	Track address	One of 256 tracks.
15		Not used.

4.1.3.3 DISK ADDRESS REGISTER DURING GET STATUS COMMAND

The Get Status command is used not only for the Get Status function, but also
for other functions that do not appear on a DEC RL01. Which function is to
be executed is determined by the setting of the Disk Address register. The
functions that can be executed are Get Status, Format, Read Cylinder 0, Write
Cylinder 0, and the DEI tape drive commands.

The bits are encoded as follows:

```
  15    14    13    12    11    10    9     8     7     6     5     4     3     2     1     0
 _____
|     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
|  X  |  X  |  X  |  X  |  X  |  X  |  X  |  X  |  X  |  X  |  X  |  X  | RST |  X  |  1  |  1  |
|_____|_____|_____|_____|_____|_____|_____|_____|_____|_____|_____|_____|_____|_____|_____|_____|
```

GET STATUS   If bit 3 (the Reset bit) is on, soft Drive Errors
              will be cleared before the status word is sent.
              If bit 1 is cleared and bit 0 is on, an OPI error
              will result.

```
  15    14    13    12    11    10    9     8     7     6     5     4     3     2     1     0
|-----|-----|-----|-----|-----|-----------------------|-----|-----|-----|-----|-----|-----|-----|-----|
|  X  |  1  |  0  |  0  |  0  | <--TAPECOM--->|  X  |  X  |  X  |  X  |  X  |  X  |  X  |  0  |
|-----|-----|-----|-----|-----|-----------------------|-----|-----|-----|-----|-----|-----|-----|-----|
```

Execute a command on the tape drive where TAPECOM
is defined below:

0	-	read block
1	-	write block
2	-	rewind
3	-	backspace block
4	-	erase block
5	-	forward-space block
6	-	select track
7	-	no operation

```
  15    14    13    12    11    10    9     8     7     6     5     4     3     2     1     0
|-----|-----|-----|-----|-----|-------------------------|-----|-----------------------------------|
| R/W |  0  |  0  |  0  |  0  | <--TRACK ADDRESS-->| HS  |<-------SECTOR ADDRESS------>|
|-----|-----|-----|-----|-----|-------------------------|-----|-----------------------------------|
```

Access unused portion of disk (physical track 0).
TRACK address must be from 0 to 5 (decimal).
If the R/W bit (15) is set, a read is performed.
Otherwise, a write is executed.
Sector address must be even.

4.1.4 MULTIPURPOSE REGISTER

The multipurpose register is used during a Get Status command to return status
bits and during read/write commands as a word count register.

4.1.4.1 MULTIPURPOSE REGISTER DURING GET STATUS COMMANDS

The following bits are present in the multipurpose register after execution
of a Get Status command.

```
  15    14    13    12    11    10    9     8     7     6     5     4     3     2     1     0
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
|  0  | WF  | WL  |  0  |  0  |  0  |  0  |  0  |  0  | HS  |  0  |  1  |  1  |  1  |  0  |  1  |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
```

WF	Write Fault	Indicates that an error occurred at the drive during writing.
WL	Write Locked	Indicates that the selected drive is write-protected.
HS	Head Select	Indicates the currently selected head of the selected drive.
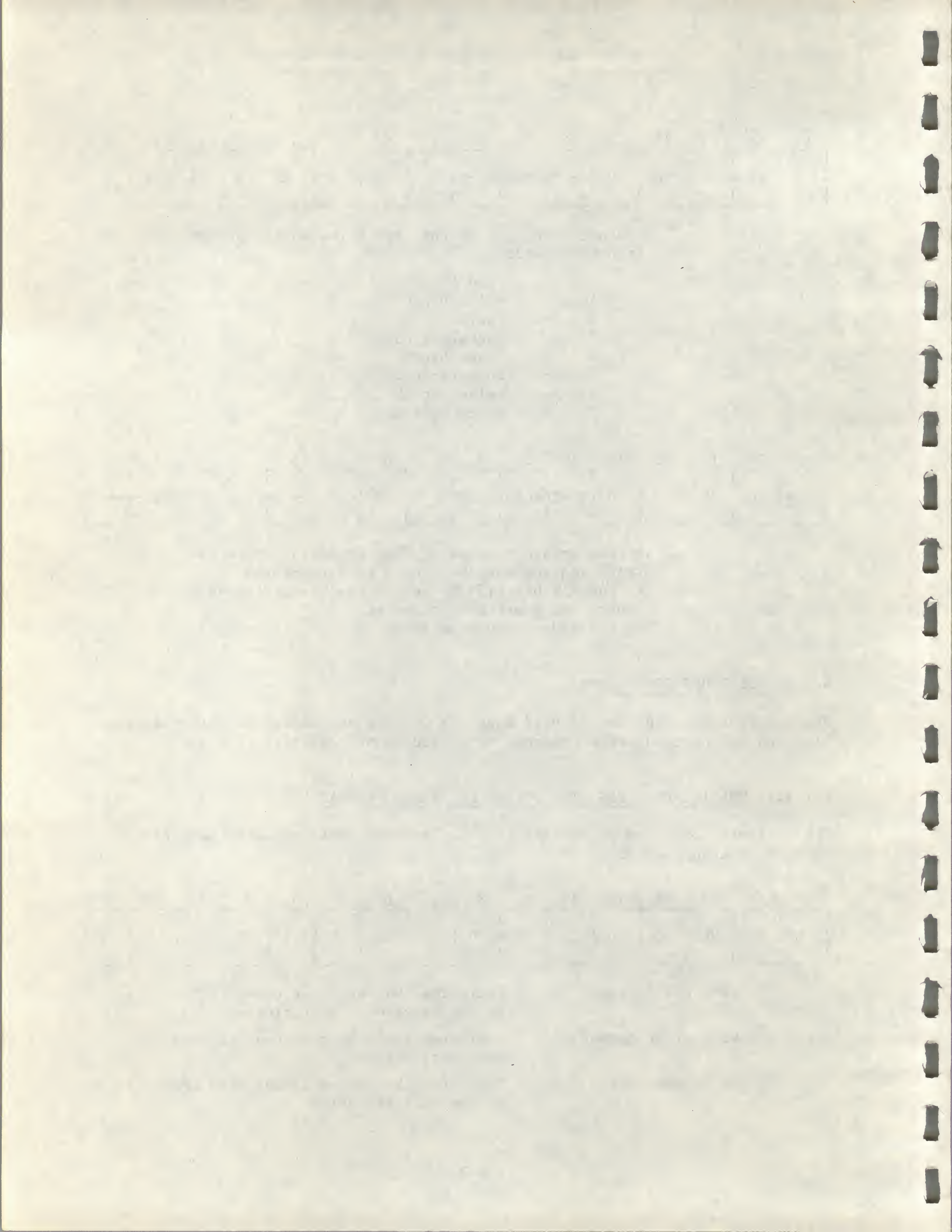
4.1.4.2 MULTIPURPOSE REGISTER DURING READ/WRITE COMMANDS

This register is loaded with the 2's complement of the number of words to be transferred and is incremented by 1 each time a word is transferred. Execution of a Read or Write command is terminated when this register reaches 0. The word count cannot be read from this register, only written.

Only 40 sectors, at most, can be transferred from the HD-11 during any one command. The sector counter does not overflow into either the head select bit or the track address register, therefore no transfer is possible after sector number 40 is reached.

The maximum word count is therefore 5120 (decimal) or 12000 (octal) and is specified in bits 0-12 of the multi-purpose register. Bits 13-15 must be set to 1.

4.1.4.3 MULTIPURPOSE REGISTER DURING READ HEADER COMMANDS

When a Read Header command is executed, the multipurpose register will contain the track address, head select bit, and sector address of the header read. This information will be presented in a format identical to that of the disk address register during a Read/Write command (see Section 4.1.3.2).

4.1.4.4 MULTIPURPOSE REGISTER DURING TAPE COMMANDS

For the tape Read Block and Write Block functions, the multipurpose register is loaded with the 2's complement of the number of words to be transferred. The maximum word count is 65535 (decimal).

For the tape Backspace Blocks and Forward-space Blocks functions, the multi-purpose register is loaded with the number (not the 2's complement) of blocks to be skipped. The maximum is 65535 (decimal).

For the tape Erase Block function, the multipurpose register is loaded with the number (not the 2's complement) of words in the block to be erased. The maximum is 65535 (decimal).

The tape Rewind, Select Track, and No Operation functions do not use the multi-purpose register.

4.2 DISK COMMANDS

Commands are issued to the HD-11 in accordance with the register description given in Section 4.1.1 of this manual. All commands including the NOP command will set CRDY when completed and interrupt at the conclusion of a command if bit 6 of the command word is set.

The NOP command is executed for function codes 0, 1, and 7. Functions 1 and 7 which are the Write Check command and Read Data Without Header Check command on the RL01 are unnecessary on the HD-11 because of differences in the hardware and are, therefore, executed as NOP's.

4.2.1 GET STATUS COMMAND (2)

If the Get Status bit (bit 1 of the disk address register) is set and bit 0 of the DA register is set), the controller will load the multipurpose register with the disk's status. This may be executed any time CRDY is set.

If bit 3 on the disk address register is set, the Head Current Error bit will be cleared (if the error condition does not still exist) before the status is loaded into the multipurpose register.

4.2.2 SEEK COMMAND (3)

This command updates the controller's record of which track (and head) the selected RL01 pseudo-drive is theoretically on, so that it can be correctly reported by the Read Header command, but no seek takes place and the Drive Ready (DRDY - bit 0 of the CS register) bit stays on. (The seek takes place when the Read Data or Write Data command is given. The controller doesn't need the seek information because the desired track and head is given again in the Read Data and Write Data commands). Because the HD-11 is physically one drive, not four, overlapped seeks are of no performance benefit. They are accepted, however, to retain software compatibility.

4.2.3 READ HEADER FUNCTION (4)

This function may be used to ascertain the theoretical position of the head on the selected RL01 pseudo-drive. When this command is executed, the MP will contain the header information described in Section 4.1.4.3. This information represents the sum of the seeks given for the selected drive and nothing else (the sector bits are zero). This command is retained only for software compatibility.

4.2.4 WRITE DATA (5)

When this command is executed, the controller uses the contents of the disk address register to determine the sector, track, and head address. When the correct sector is found (after a rotational latency) and the header is checked, data is written into the sector's data field. This data was received by means of a DMA read operation. If the word count register overflows before the end of a sector, the remaining bits are written as 0. Successive sectors up to sector 40 are written until the word count register (multipurpose register) overflows. After execution is completed, CRDY is set.

4.2.5 READ DATA (6)

This command is similar to the Write Data command choice except that data is read from a sector's data field and then a DMA write will move the data to the system's memory. The CRC is checked for each sector and an error is returned if either a correctable or non-correctable error occurs. It is assumed that a retry of this read will be attempted. The next Read command executed will read the sector a second time. If a correctable error occurs, this time it will be corrected and no error bit or any indication of an error will be returned. Of course, if an uncorrectable error occurs, a normal CRC error status bit will be returned.

This implementation was made in order to be compatible with the RL01 which is a non-correcting device and yet not hide correctable errors to either an error-logging system or a diagnostic test.

4.3   TAPE COMMANDS

A command is given to the tape drive by doing a Get Status command with the
Disk Address register set as specified in Section 4.1.3.3.

4.3.1   READ BLOCK - FUNCTION 0

The controller assumes that the tape is rewound or properly positioned in an
inter-block gap, and that the number of words specified in the multi-purpose
register is the number of words in the next block. It then reads the next
block into memory, starting at the location specified by the bus address
register. If the word count is too large, a "missing data" error will probably
result. The multi-purpose register has the two's complement of the word count.

4.3.2   WRITE BLOCK - FUNCTION 1

One block is written on the tape from memory starting at the address specified
in the Bus Address register. The length of the block in words is specified in
the multi-purpose register as its two's complement. The write begins at the
current position of the tape.

4.3.3   REWIND - FUNCTION 2

Bus address and word count are not used. The controller returns as soon as the
rewind is initiated, and the tape drive completes the rewind. The disk can be
used while the tape is rewinding. A tape command given during the rewind will
not return until the rewind is done.

4.3.4   BACKSPACE BLOCKS AND FORWARD-SPACE BLOCKS - FUNCTIONS 3 & 5

For these functions, the number (not the two's complement) of blocks to skip
is placed in the multi-purpose register. WARNING: If the blocks are less than
2K words long, these functions can overshoot by as many as eight blocks (depend-
ing on how small the blocks are). Also, forward space can undershoot by one if
the target gap is long enough (for example, due to an erased block). Back-
spacing one block will work correctly if the block is more than 128 words. The
Bus Address register is not used.

4.3.5   ERASE BLOCK - FUNCTION 4

The number (not the two's complement) of words in the block to be erased is
placed in the multi-purpose register. The Bus Address register is not used. The
erase is timed by the controller according to the number of words in the block
to be erased, such that the entire block is guaranteed to be erased. Because
of variations in tape speed, though, about 6% more than that can be erased.
The erase begins at the current position of the tape.

4.3.6   SELECT TRACK - FUNCTION 6

The track indicated by bits 8 and 9 in the Control and Status register is
selected. The Bus Address register and multi-purpose register are not used.
This function should only be executed when the tape is rewound, because switch-
ing tracks can cause a glitch on the tape (any track) that can ruin data written
on the tape.

4.3.7   NO OPERATION - FUNCTION 7

This function is useful because it will return the Early Warning Sensed bit
(bit 10 of the CS register) and the Drive Not Ready error, if it occurs, without
executing a command.
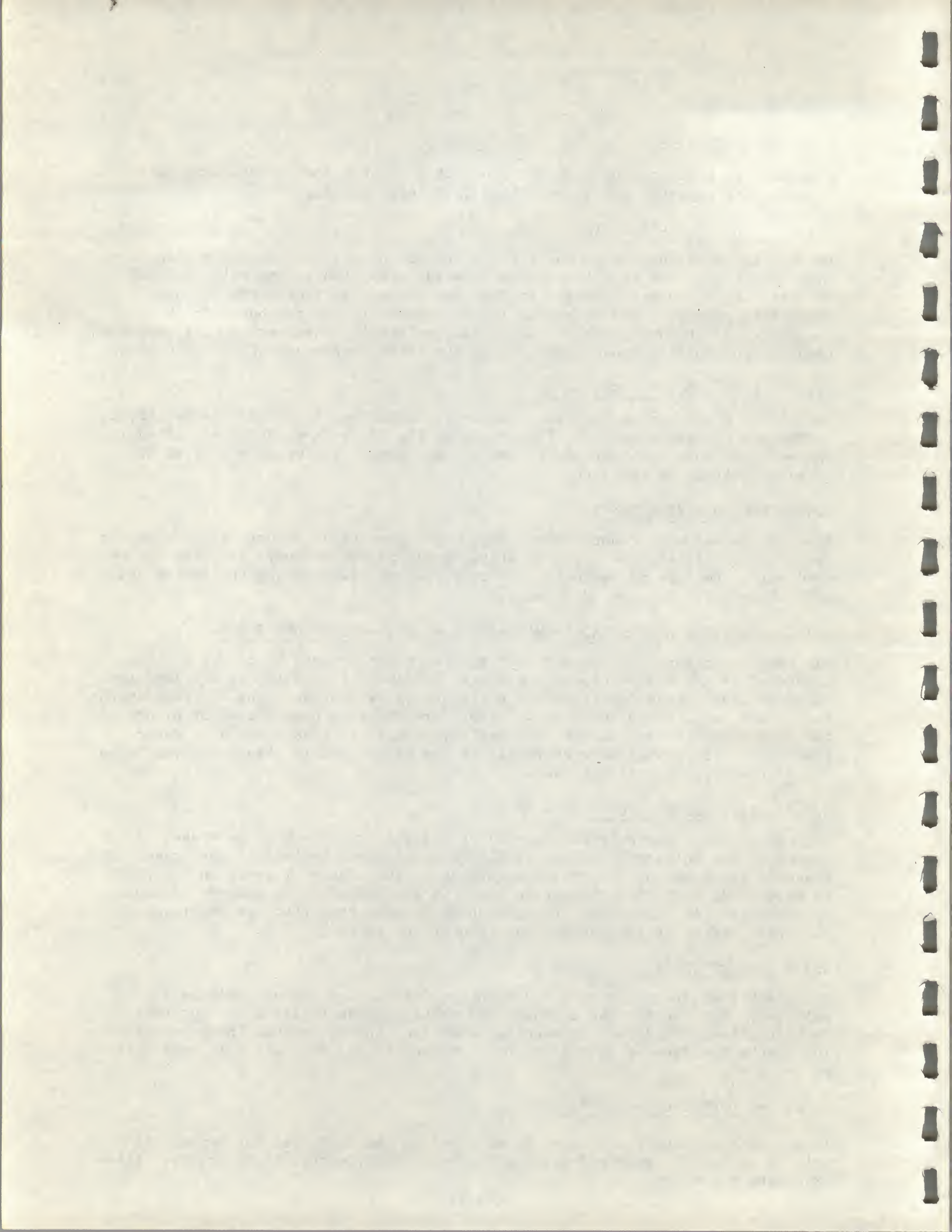
4.4 SPECIAL AREA OF THE DISK

The "special area" of the disk is an otherwise unused part of the disk not associated with any of the four RL01 images emulated by the HD-11. It is physically located on SA4008 cylinder zero and consists of the entire cylinder. This cylinder is guaranteed good by the manufacturer and therefore is used to hold the Track Reassignment File (see Section 3.6). It also holds the support programs provided by CRDS described in Section 5.2. Booting these programs is described in Section 3.7.

The "special area" appears as a small RL01 unit containing 12 RL01 tracks (240 blocks). Reading and writing this area is described in Section 4.1.3.3. Note that to write the "special area" of the disk, the format jumper described in Section 3.8 must be installed. This area should not normally be written and its use other than provided for by CRDS is not guaranteed. This information is provide only for completeness.

Section 5

UTILITIES AND DIAGNOSTIC SOFTWARE

5.1 BOOTSTRAP PROGRAM

The HC-210 contains a 256-word read-only memory starting at location 773000.
This memory contains bootstraps for the following devices:

Mnemonic	Device	
DLn	HD-11 or RL01	Will bootstrap any of four units
DYn	RX02	Will bootstrap floppy disks in either unit 0 or 1.
DXn	RX01	Will bootstrap floppy disks (single density, programmed-controlled) in either unit 0 or 1.
SP	HD-11, physical track 0	Bootstraps CRDS-supplied software from special area on HD-11.
TP	HD-11-T	Bootstraps program on 3M cartridge tape.

To use this bootstrap, start execution of the LSI-11 at location 773000.
This may be done by either typing 773000G to ODT or by doing an INIT on
a processor strapped for power-up mode 2.

The console monitor will then type an asterisk. Any of the five mnemonics
above may then be typed in, followed by a carriage return. The lowercase
letter n above is used to denote the unit number. No unit number is speci-
fied on the SP or TP mnemonic.

It should be noted that the DX and DY mnemonics lead to identical entry points;
in actuality, RX01's are distinguished from RX02's by the "RX02 bit" (bit 11)
of its CSR (177170).

The SP mnemonic boots in CRDS-supplied special programs from the special area
of the disk. If the user has another bootstrap memory enabled at location
773000, he must type in the SP bootstrap given on page 37.   When the SP
is booted, a menu appears allowing user selection of the particular function
desired.
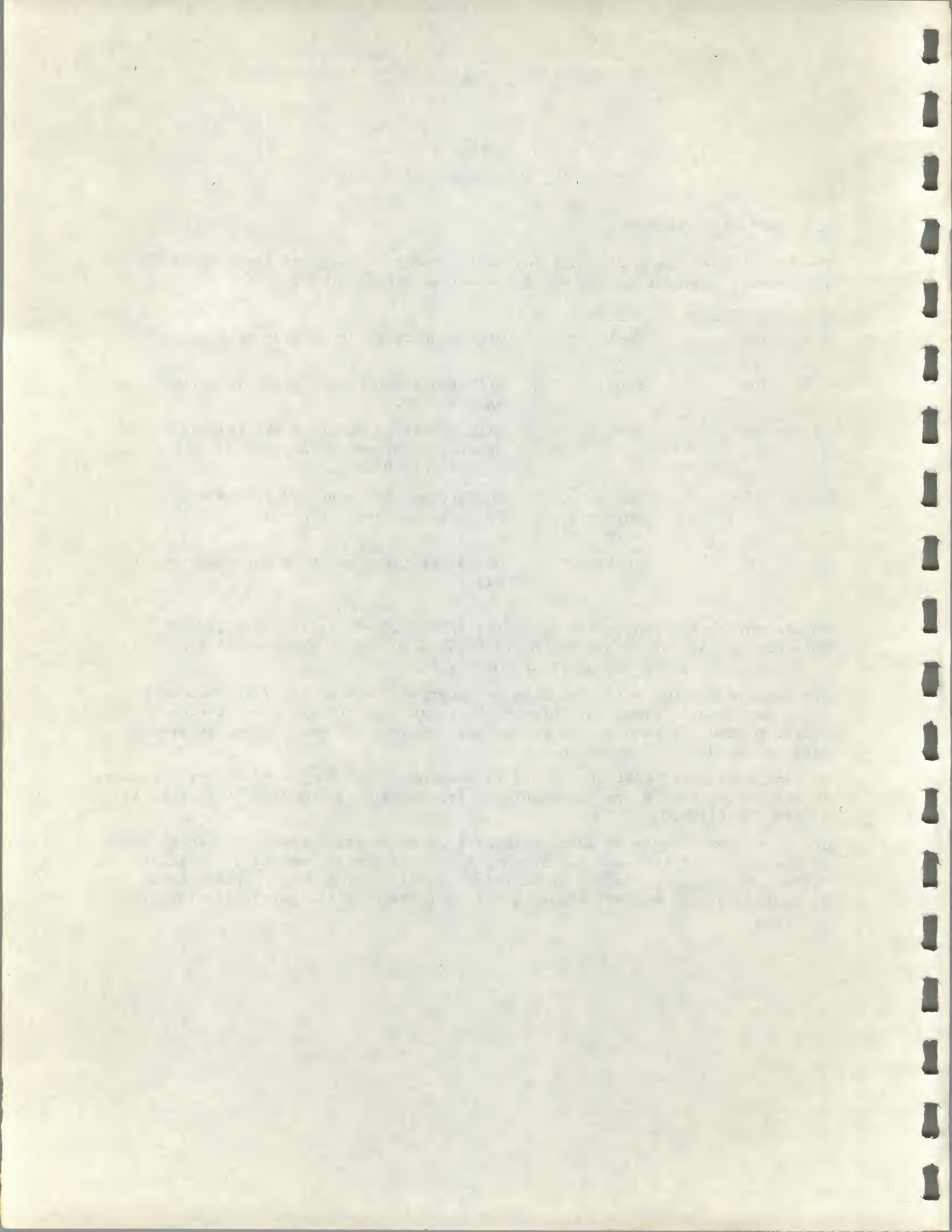
5.2 SPECIAL PROGRAMS

The special programs provided by CRDS are (1) a formatting routine for the
disk drive, (2) a disk diagnostic to test the drive, controller and interface,
(3) a program to update the disk's Track Reassignment File , and (4) tape
transfer and test programs.

These special programs are provided by CRDS in the following three forms:

Tape Cartridge:	readable on HD-11/T
Floppy Disk:	readable on RX02 or FD-211
HD-11:	readable on HD-11 special area

Although all HD-11's are supplied with the SP programs written on the "special
area" of the HD-11, this cannot be relied upon. These programs could be
destroyed by a hardware failure and this allows no opportunity to update these
programs. We, therefore, can only be responsible for supplying the user by
means of the removable-media devices listed above. The HD-11 "special area"
is provided to help the user on initial checkout. In addition, the tape
cartridge and floppies have a program that allows the user to transfer their
SP programs to the special area, allowing faster loading. All customers who
order a HD-11 with the tape option receive a tape cartridge with the special
programs. This tape is write-protected and should not be used for back-up.

After a successful boot, an introductory heading and software version number
(currently 3.0) is printed. The program currently requires 28K words of
memory. The controller address and interrupt vector is then requested. At
this point, if there is no programmable clock and the line time clock is not
already on, a message is printed requesting that the clock be turned on
manually. If there is no clock on the system, operations that should time
out will loop forever. A menu is then displayed allowing the user to choose
a function. The functions supported by V3.0 are formatting the disk, diagnos-
ing the disk, diagnosing the tape, dumping the disk to tape, restoring the
disk from tape, maintenance of the Track Reassignment File, transferring the
software to/from floppies, tape and disk. In addition one other function allows
selecting options such as terminal line length, line frequency, and a maximum
number of errors that will cause testing to stop.

Many questions are asked by the SP software that require some response by
the user. Most questions have default answers that are shown in parentheses.
Typing just a carriage return in response to a question is the same as typing
in the default value shown. Questions requiring yes or no answers will accept
several forms of yes or no including y/n, yes/no in both upper and lower case.
Input may be edited with the DELETE (or RUBOUT) character to delete the last
character entered and the control U ($_\wedge$U) character to delete the entire line.

In addition to character delete and line kill processing features, other text-
handling characters include control S ($_\wedge$S) to suspend all terminal output,
control Q ($_\wedge$Q) to resume terminal output, control O ($_\wedge$O) to flush all output
until another character or control P ($_\wedge$P) is typed. Control P will not cause
any information to be entered into the computer.

The escape character ($_\wedge$[) reinitializes the system and restarts the software
in the last function selected, and control C ($_\wedge$C) has a different meaning
for each function and is described in the section for that function.

5.2.1 FORMATTING PROGRAM

This program writes headers onto the HD-11 disk drive. This program should not be used unless it appears that headers on the disk cannot be read. This program destroys data on the disk. Therefore a jumper has been implemented to provide a safeguard against accidental initiation of this function. The jumper described in Section 3.8 must be installed to allow the format function to operate. The user may format either the special area of the disk, the entire disk except for the special area, or a small segment of the disk that incorporates a particular unit and block number. When a unit number and block number are given, the program displays what other units/blocks will be affected. Formatting the special area will destroy the support software and more importantly, the Track Reassignment File (see Section 3.6) and a message to that effect is printed. The format program then awaits confirmation of the desire to format. It also requests installation of the format-enable jumper. All interrupts are disabled during formatting. After formatting headers of the requested area, the software will request that the format jumper be removed. Then data is written to the formatter area to create the data fields.

5.2.2 HD-11 DISK DIAGNOSTIC

The diagnostic program consists of 19 functionality tests for the HD-11 disk system. These tests are described in Section 5.2.2.2. The diagnostic program allows each test to be individually selected and run. The selected tests may be run for a requested number of passes or continuously. After the requested number of passes have been completed, an error report summary is generated detailing the number of failures of each test. Note that one test may cause several errors in one pass. The sector uniqueness verify test (19) is not normally used, but its use is explained in Section 5.2.9.

Normally, no messages or signals of any kind are printed unless an error is encountered or the end of the requested number of passes has been completed. However, the user may at any time, by typing the control C character (^C), find out what test is running, which pass number is being performed and get an error report summary. The escape character will, at any time, restart the diagnostic from the initial menu described below.

5.2.2.1 TEST SELECTION

Since some combinations of tests are used more frequently, several of them are built into the program. When the program begins, it will ask whether options should be changed. At this point the user may turn on or off error logging to the floppy disk in addition to selecting options described in Section 5.2.7. The software will then display the following menu:

        0:    Tests by List
        1:    All tests
        2:    Basic tests
        3:    Quick tests
        4:    Read only tests
        5:    Read/Write disk
        6:    Random exerciser
        7:    Drive test
        8:    Board test
        9:    Overnight test

Each of these choices is described below.

0: Tests by List

        The program displays all of the basic tests and asks for a list of
        tests. The list may be a combination of test numbers separated by
        commas. If two tests numbers are separated by a '-', then all tests
        between are included as well.

                Example: 1,2,4-6   means   1,2,4,5,6

        The program then asks for number of passes and halt-on-error flag.

1: All Tests

        Runs all 18 tests;

                Tests: 1-18
                Passes: 10
                Halt-on-error: Yes

2:   Basic Tests

Runs very simple test functions.

        Tests: 1-8
        Passes: 10
        Halt-on-error: Yes

3:   Quick Tests

Runs all tests which complete in a short amount of time.

        Tests: 1-8, 10, 12, 13, 14, 16
        Passes: 10
        Halt-on-error: Yes

4:   Read only Tests

Runs only those tests which do not issue write commands.

        Tests: 1, 6, 8, 10, 11
        Passes: 10
        Halt-on-error: Yes

5:   Read/Write Disk

Runs the read/write test. Useful for checking the disk media.

        Tests: 17
        Passes: 1
        Halt-on-error: Yes

6:   Random Exerciser

Tests the disk using random reads and writes.

        Tests: 18
        Passes: forever
        Halt-on-Error: No

7:   Drive Test

Runs those tests which mainly test the drive

        Tests: 14, 15, 17
        Passes: 1
        Halt-on-Error: Yes

8:   Board Test

Runs those tests which mainly test the controller board

        Tests: 1-8, 10-16, 18
        Passes: 1
        Halt-on-Error: Yes

9:   Overnight Test

Runs all tests except for the write protect test which requires
manual intervention

        Tests: 1-8, 10-18
        Passes: Forever
        Halt-on-Error: No

5.2.2.2 TEST DESCRIPTIONS

The following is a description of each of the tests available in the diagnostic.

Test 1: Register Addressable Test

This test checks that the four HD-11 registers are present. An attempt is made to read and write each register.

Note: If this test is requested and the test fails, no other tests will be attempted.

Test 2: Register Reset Test

This test verifies that the HD-11 registers are in the proper state after a bus reset. A reset is issued, then each register is checked for the proper value.

Test 3: Register Uniqueness Test

This test performs two functions.
     1) Bits within a register are independent
     2) Writing into one HD-11 register does not change the others
Each register is tested in turn. A sequence of words (walking and growing ones and zeroes) is written into the register. The value is then read back and checked. The other registers are then checked to verify that they are unchanged.

Test 4: Get Status Test

This test checks the operation of the Get Status function. There are four parts.
     1) Get Status completes successfully.
     2) Get Status operation sets the OPI error bit when the
        Get Status bit is not set in the Disk Address register.
     3) Verifies that an interrupt occurs when Get Status completes.
     4) Verifies that an interrupt occurs when OPI is set [like (2)].

Test 5: Read Header Test

This test checks the operation of the read header function. First, a read header command is given. The test verifies that the command completed normally and that an interrupt occurs when requested. Then, the test issues repeated read header commands, checking that the track address returned is the same.

Test 6: Basic Seek Test

This test verifies that the seek function completes normally and that an interrupt occurs when requested.

A read header command is issued after the seek command to check that the correct track has been chosen.

Test 7: Basic Write Test

This test checks that the write function completes properly.
A write is issued to Unit 0, track 0, sector 0. Five things are
checked.
1) The processor was able to continue executing (i.e., a trap
   to loc. 4 did not occur).
2) The bus address register incremented properly.
3) The disk address register incremented properly.
4) The buffer contents did not change.
5) The ability of the write function to generate an
   interrupt is also checked.

Test 8: Basic Read Test

A read is issued from Unit 0, track 0, sector 0. Five things are
checked.
1) Trap through location 4 did not occur.
2) Bus address register incremented.
3) Disk address register incremented.
4) The data in the buffer changed
5) The ability of read to interrupt is checked.

Test 9: Write Protect

This test has four parts.
1) The user is asked to turn the write protects off.
   Get Status commands are issued for each unit to verify
   that the write lock bit is off.
2) The user is asked to turn the write protects on. The
   Get Status command is used to check that the write lock
   bit is on.
3) A write is issued to the disk. The drive error bit
   should be set.
4) The data is read back from the disk to see if the write
   actually occurred.

Note: This test is run only on pass 1.

Test 10: Header Compare (Read Only)

This test checks the header compare logic. Each sector (0-39) on
track 0, unit 0, is read into memory. If the proper sector is
not found, a Header-not-found error will be indicated.

Test 11: Seek Test (Read Only)

This test checks the head positioning mechanism and head select
logic of the drive. Approximately 10% of the tracks on the drive
are tested. For each one of these tracks, the following occurs:
1) A seek to unit 0, track 0 and read command
2) A seek to the selected track and read command
3) A seek to Unit 3, track 254 and read command
4) A seek to the selected track and read command
If at any time the seek does not occur correctly, the proper header
will not be found and a header-not-found error will result.

Test 12:   Data Paths Check

This test checks that data can be written and read back from the disk.
Each of 64 data patterns is written on sectors 0 and 1, track 0 of unit 0.
The data is then read and checked.

Test 13:   One Track R/W

This test is intended to exercise the disk to its maximum throughput.
One track (40 sectors) is written with each of eight data patterns.
After each pattern is written, it is read and verified to be correct.

Test 14:   Sector Uniqueness Test

Write each sector on the disk with the address. Then read the disk
to verify that each sector contains the proper value.

Test 15:   Seek Test (R/W)

Same as Test 11 except tracks are first written with track address
information in order to further verify the seeking function. Test 11
is a read-only test, this is read/write.

Test 16:   DMA-Test

This test checks the DMA word count. A known pattern is written on
the disk. The data is then read, using word counts of 1-128. The
test checks that the proper number of words were transferred.

Test 17:   R/W Complete Disk

This test writes all sectors on the disk. Then it verifies that the
data has been written correctly. Three data patterns are used:
        1) all zeroes
        2) all ones
        3) binary 011011011 ..... (the worst case data pattern)

Test 18:   Random Exerciser

This test tests the ability of the disk to handle arbitrary requests.
A random disk location, transfer length, and data pattern is chosen.
The pattern is written on the disk. A new transfer is chosen and
the pattern is written. Then the original pattern is read and checked.
This test continues for two minutes.

Test 19:   Sector Uniqueness Verify

This test checks that the pattern written in Test 14 is still on the
disk. Its use is described in Section 5.2.9.

5.2.3 TRACK REASSIGNMENT FILE UPDATE PROGRAM

This function allows creation and modification of the Track Reassignment File
described in Section 3.6. The format jumper must be installed to do this.
Modifying the Track Reassignment File will cause data on the disk to be lost
and probably render useless the entire contents of the disk. Therefore, upon
entering this routine, the user is warned of the hazard and is requested to
confirm the desire to modify/create the Track Reassignment File. Users should
normally dump the entire contents of the disk before making changes to the
Track Reassignment File, then restore the dumps after modification.

After confirming the desire to modify the Track Reassignment File, the user is
asked to install the format jumper (see Section 3.8). After confirming install-
ation of the jumper, the program allows the user to choose between creating the
file from scratch or updating the existing file. After completion of the changes,
the program requests that the format jumper be removed, then data areas are writ-
ten to any new piece of the disk.

5.2.3.1 CREATING THE TRACK REASSIGNMENT FILE FROM SCRATCH

Creating the file from scratch is normally done by CRDS using information
provided by the manufacturer of the drive. The manufacturer runs tests under
marginal conditions and a list of bad areas is affixed to the drive chassis
under the HC-300 card. When choosing to create the file from scratch, the in-
formation is entered by absolute cylinder and head number. A null entry termi-
nates the list of entries. The user is then asked whether the list is correct.
If not, the user will be asked to modify the list as described in the next section.
Otherwise, the list is written to the disk (also described in the next section).
Users will have to enter the information in this form if they have formatted the
"special area" of the disk (see Section 5.2.1).

5.2.3.2 MODIFYING THE TRACK REASSIGNMENT FILE

If a user desires to modify the existing Track Reassignment File, the HD-11
support software will read it from the disk. Any errors in reading will cause
a message to be printed and the routine will exit. The user must then choose
between modifying the file in terms of absolute cylinder/head numbers or unit/
block numbers (the default). Choosing to use cylinder/head numbers allows one
to see the existing list of bad tracks, but the correspondence to RL01 units
and block numbers is lost. Choosing unit/block numbers does not allow the
user to see existing bad tracks since there is no equivalent "bad block"
number, but does allow the user to add entries by simply specifying unit/block
numbers as seen by the operating system. In either case, the list can be
modified by removing existing entries, then adding new ones until the list
is correct.

The software will always convert a list of bad unit/block numbers to unique
cylinder/head numbers and store the information in that form. The Track
Reassignment File is then written to the disk in the special area (see
Section 3.6) and is read back for verification. If there is any hard error
during the writing or read back, the user is informed and asked whether it
should be tried again.

5.2.4   SOFTWARE TRANSFER PROGRAM

This program will transfer all the CRDS-supplied utility software between HD-11 disk, HD-11 tape and RX02 compatible floppy disks. Upon entry to this program, the user is requested to enter the "from device" and "to device" by choosing a number from 1 to 3 corresponding to disk, tape or floppy, respectively. The disk or tape controller address used by this program is the one entered when the utility software was booted (see Section 5.2). If the floppy is chosen as either a "from" or "to" device, the user is then asked to enter the floppy controller address and the unit number. If the disk is chosen as the "to" device, the user is asked whether the format jumper is installed.

Once devices are selected, the program writes an appropriate bootstrap block to the "to" device and proceeds to copy the software from the selected "from" device to the selected "to" device. Not that when copying to the disk, the "special area" should already be formatted. If for some reason it is not, you must first format the "special area" as described in Section 5.2.1. Normally the "special area" will be formatted, but if it is not and you are reformatting it, pay special attention to the warnings in Section 5.2.1 about formatting the "special area" since the Track Reassignment File will be des- troyed.

Any hard errors encountered during the copy are reported and then cause the program to end. Once ended, due to errors or simply completed, the program will return to the main menu described in Section 5.2.

5.2.5 TAPE DIAGNOSTIC

The tape diagnostic program includes eight tests for the HD-11 tape system. Each of these tests is described in Section 5.2.5.2. The tests may be run for a specified number of passes or continuously.

When the program begins, it asks the user if options should be changed. Changing options allows logging to be turned on or off. Then, it asks the user if soft errors should be reported. A NO answer (the default) causes the program to suppress the reporting of soft tape errors.

5.2.5.1 TEST SELECTION

The program will type a "menu" of test combinations. It will then ask for a test number. Typing an empty line will exit the tape diagnostic program. The menu displayed is:

                0   Tests by list
                1   Drive test
                2   Media test

0: Tests by list

    This entry allows the user to run an arbitrary combination of tests. The program asks for a list of tests. The list may be any combination of test numbers separated by commas. If two numbers are separated by a '-', then all tests between are included as well.

    The program then asks for the number of passes and whether or not it should halt on an error.

1: Drive Test

    Tests the functions of the drive.

        Tests: 1-3, 8
        Passes: 5
        Halt-on-Error: No

2: Media Test

    Runs the read/write tests to check the tape cartridge.

        Tests: 4-7
        Passes: 1
        Halt-on-Error: No
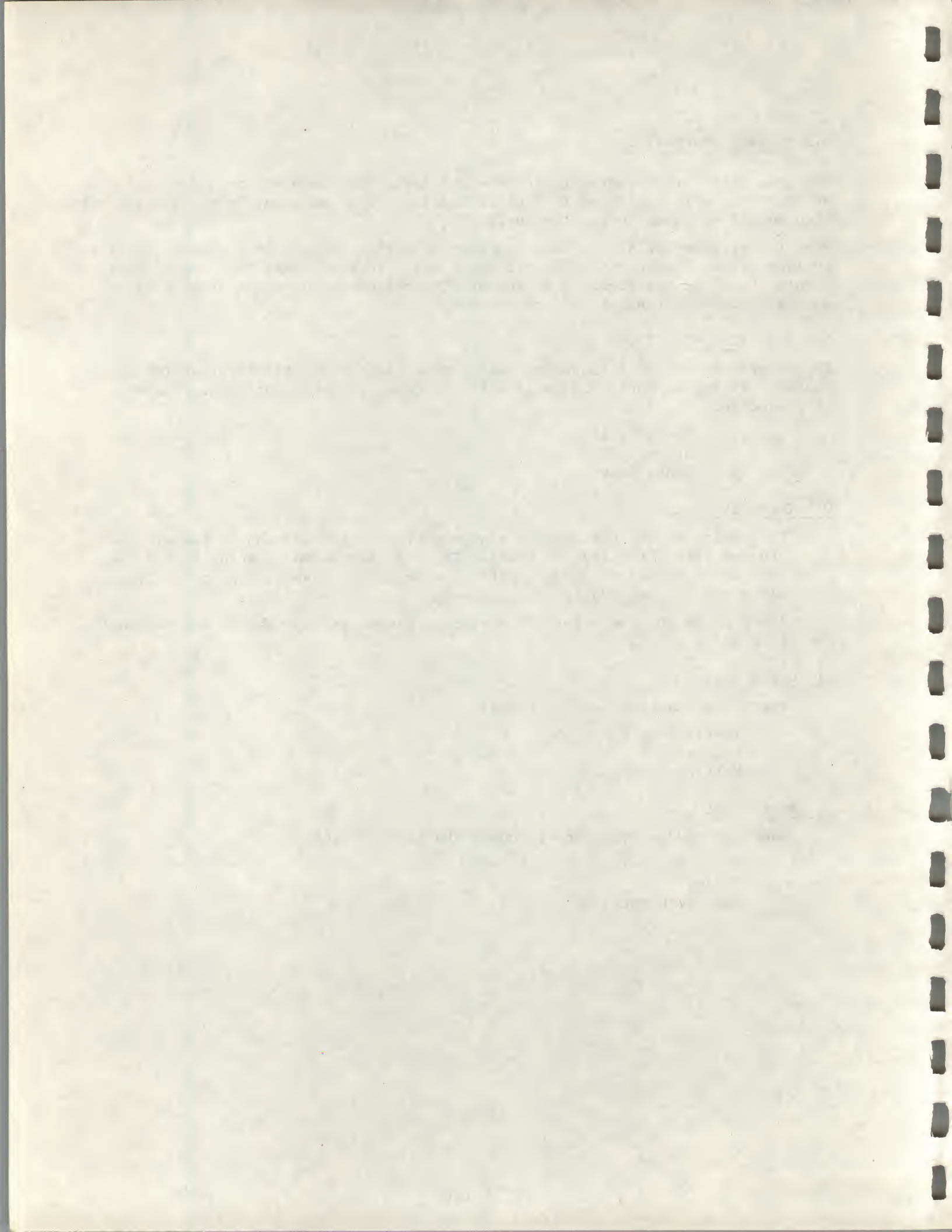
5.2.5.2 TEST DESCRIPTIONS

This section describes each of the tests available in the diagnostic.

1. Write/protect

This test checks the write-protect logic on the drive. The program
requests that a write-protected cartridge be inserted into the drive.
The program then waits until the drive indicates that a cartridge is
present. After the cartridge has been inserted, a write command is
issued. The program verifies that the proper error was indicated.
The user is then requested to insert the unprotected cartridge so
that testing may continue.

Note: This test is run only on pass 1.

2. Quick test

This test checks many of the functions of the tape unit. It has four
parts:

1) Four different data patterns are written on the four tracks of
    the tape. The program then verifies that the track selection
    logic is performing correctly by reading each block and checking
    for the correct data.

2) Two new blocks are written on track 0 of the tape. The tape
    is then rewound and the blocks are read. The tape remains
    positioned after the second block.

3) This part checks the backspace function. The tape is backspaced
    over one block (the second block from (2)). The data is checked
    to verify that the correct block was found.

4) The second block is erased, then a new block is written on the
    tape. The tape is rewound, and both blocks are read. The data
    is checked to verify that the erased block is skipped properly.

3. Seek Test

This test exercises the forward space and backspace functions. Track 0
is written with 10K word blocks containing the tape block number. The
tape is moved to the midpoint. Space commands are issued in alternating
directions, increasing in length at each step.

4-7. Read/write tracks

Each of these tests writes as many 10K word blocks as possible on the
specified track. The data is then read to verify that it is correct.
If less than 195 blocks can be written, a warning message is printed,
since the tape probably cannot be used for 3-per-tape backup dumps.
This can be due to any combination of 1) too many tape errors, 2) a
short tape, or 3) a faster than normal tape drive.

8. R/W Zeroes

This test is mainly for helping CRDS to diagnose controller CRC logic.
Track 0 is written with one 10K word block of zeroes. The data is then
read and verified.

5.2.6 DUMP/RESTORE PROGRAM

The Dump and Restore Program provides a method for saving and retrieving RL01 images on the HD-11-T magnetic tape. This program may be used for creating backup copies or for saving and restoring the disk when the Track Reassignment File is updated (see Section 5.2.3).

There are two different tape formats used by the dump/restore program. One format allows two RL01 images on a tape, while the second allows three RL01 images on a tape. While the three-per-tape format allows more data on the tape, it only has one checksum block per RL01 image and does not allow changing any part of the tape after it is written. The two-per-tape format has 8 checksum blocks per RL01 image and allows independent updating of either of the two images on the tape.

5.2.6.1 DUMPING TO TAPE

The dump program first requests the user to select a dump tape format by specifying the number of RL01 images per tape as either two or three. The program then continues as follows depending upon the format specified.

Three-per-tape:
   The user is requested to enter up to three unit numbers. If less than three units are to be dumped, the sequence may be terminated by entering a blank line. NOTE: If less than three units are specified, the remaining units can not be added later.

   The user is then asked for a comment. This might include the date, time, units dumped or other information which might help identify the tape.

Two-per-tape:
   For each unit to be dumped, the program requests: 1) the unit number, 2) the tape position, 3) comment to be written on the tape. If only one unit is to be dumped, a blank line should be entered when the second unit number is requested. NOTE: Tape position "1" must always be used first on a new tape. If a previous dump tape is updated, then either position may be specified.

After the information has been entered, the program begins to write the tape.

Errors:

   The program detects errors while writing the tape. These errors are retried and bad spots are skipped. If the operation does not succeed after ten tries, a hard error is indicated.

   At the end of each unit the program will print a warning if any bad spots on the tape were skipped during the dump.

   If a hard error occurs during the dump, the program will ask if the dump should be continued. If the dump is continued, the block which caused the error is tried again.

5.2.6.2 RESTORING FROM TAPE

The restore program copies data from a tape to the specified RL01 unit. The program reads the tape to locate a "dump" header. The header contains the format of the dump tape. If no valid header is found, restore prints "not a dump tape" and aborts. If the header is valid, the program asks for a RL01 unit number and a tape position. The program then copies the data from the tape to the disk.

If an error occurs while reading the tape, a message is printed on the terminal. It gives details of the controller registers and an English word describing the error. The program will try to read the block several times. If all attempts fail, a "hard read error" message is printed.

If the restore program fails to read a block after the specified number of attempts, its location and corresponding disk address are saved for use later. When the checksum block is read from the tape, the information is used to reconstruct the original data. Reconstruction (ECC) will occur so long as only one block is defective within the checksum area. This is 1/8th of an RL01 for the two RL01's per tape format, and one RL01 for the three RL01's per tape format. A warning is given if a reconstruction occurs. Thought should be given to re-backing-up that tape. The ECC implemented here operates at the handler level.

If two or more errors should occur within the range of the same checksum block, then there is not enough information for reconstructing the data. The program will ask if the restore should continue. Other data within the range will be correct, as will be other data on the tape.

5.2.6.3 DUMP TAPE FORMAT

The dump tape contains three types of records: Header, Data, and Checksum.

Header records are 256 words. These records contain the tape format and a comment (label) supplied by the user when the dump is made.

Data records are 10,240 words. Each data record contains the information from two (2) RL01 tracks.

Checksum records are 10,240 words. Each checksum word is the sum of the corresponding word in each data record since the last checksum. This block is used to recover information should a data record be unreadable.

Three-per-tape: The tape contains one header block. Each unit dumped has 256 data block and one checksum block. Individual positions may not be updated.

Two-per-tape: The tape is divided into two parts. Tracks 0-1 are Position 1; Tracks 2-3 are Position 2. Each position may be updated separately. Each position starts with a header record.
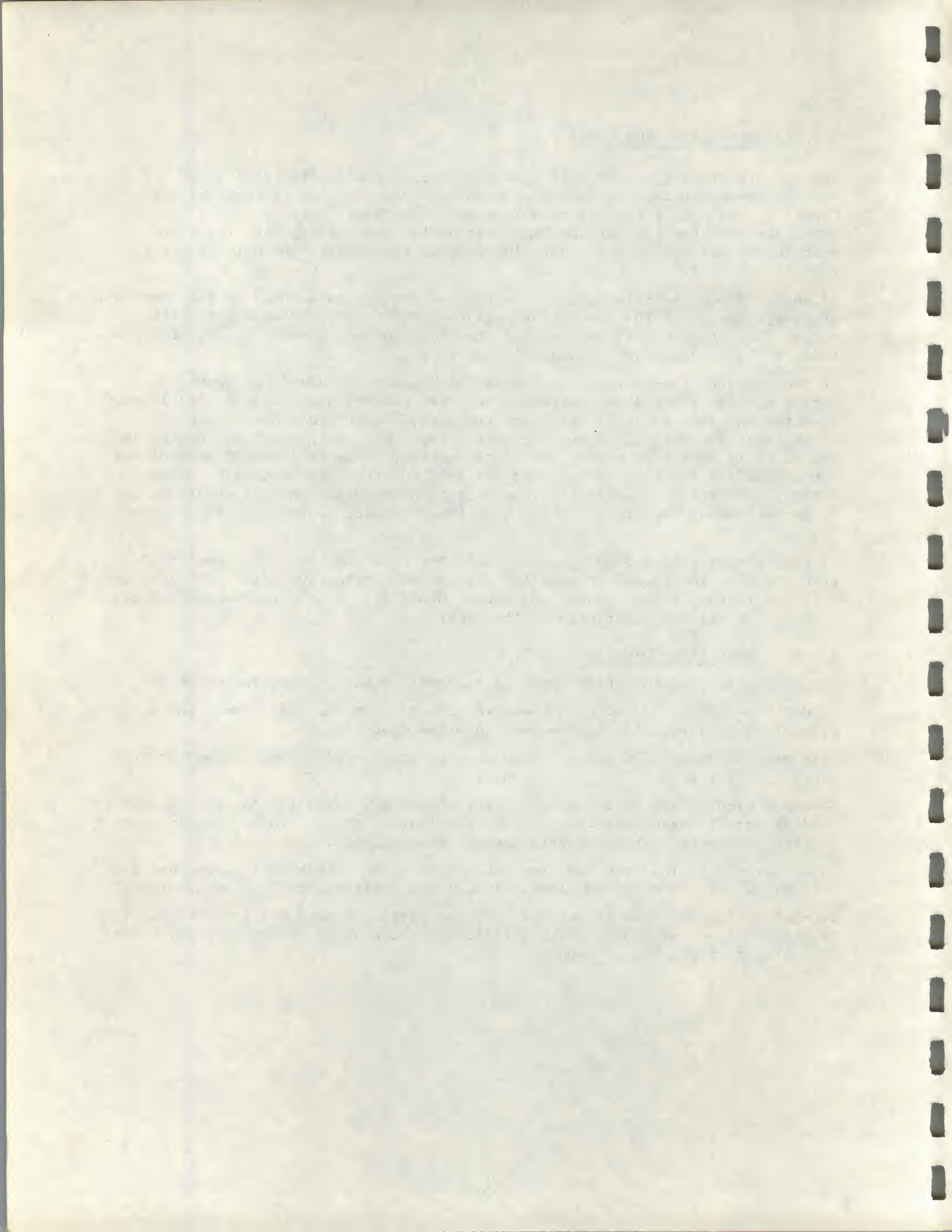
5.2.7 SELECTING OPTIONS AND THE ERROR LOG

When changing options either from the initial menu described in Section 5.2 or
from within the disk or tape diagnostics, the user answers questions regarding
terminal line length, clock frequency, and a maximum number of errors to stop at.
If a negative response is given to the question about the line frequency being
60 Hz, the software will assume that the line frequency is 50 Hz. The maximum
number of errors to stop at is used by the diagnostics to request confirmation
to proceed after encountering that many errors. This simply saves paper on a
printing terminal when the diagnostic is run overnight.

When changing options within the diagnostics, an additional question is asked
regarding error logging to a floppy disk. If an affirmative response is given,
a floppy disk controller address and unit number are requested. When enabled,
logging causes the software to record on a floppy disk exactly what is printed
on the terminal while the selected tests are run. This is useful if the terminal
is a video terminal since the error information just rolls off the screen. Flush-
ing terminal output (via control O) will not affect the continuation of logging
to the floppy disk.

Writing to the floppy disk begins at a point beyond where the HD-11 support soft-
ware is stored so that logging can be done on a floppy that contains the software.
Logging continues until either the number of requested passes have completed, the
user presses the Escape key, or the end of the floppy is reached. Logging is
automatically disabled once logging is terminated by any one of the three
methods just described. To log a new set of diagnostic runs, the option must
be reselected. To view the log, the user must return to the "top level".

5.2.8 VIEWING THE ERROR LOG

The error log (see Section 5.2.7) may be displayed by selecting that option
from the top level menu. The user is requested to enter a floppy controller
address and unit number. The log is then displayed beginning with "<START OF LOG>"
and ending with "<END OF LOG>". The log is not affected by displaying it.

5.2.9 VERIFYING THE DUMP/RESTORE PROCESS

The user may verify the complete dump/restore process by performing a sequence
of actions that:

       1)   write the disk with a known pattern
       2)   dump the disk to the tape
       3)   destroy the pattern on the disk
       4)   restore the disk from tape
       5)   verify that the known pattern exists again on the disk
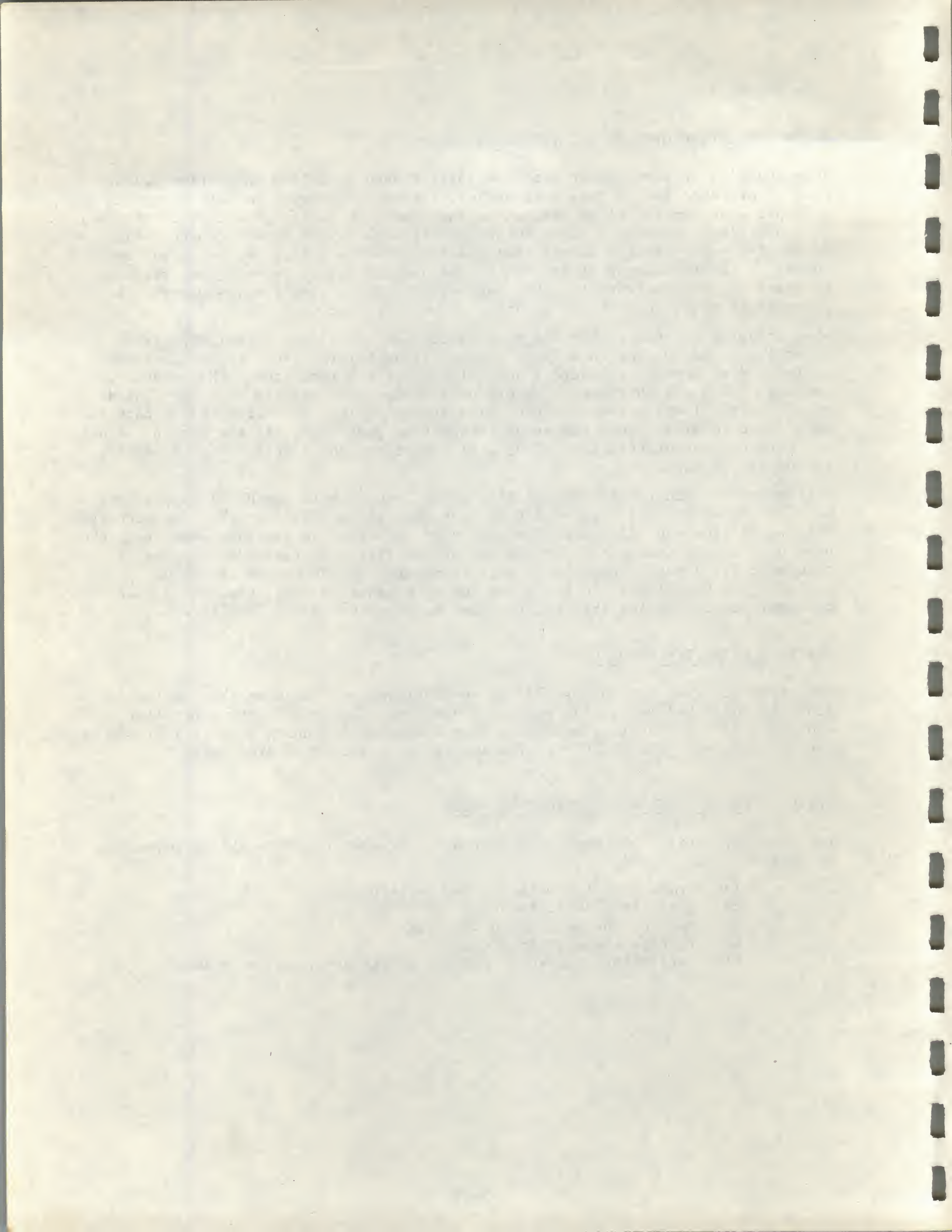
The HD-11 software has all the necessary components to perform this sequence.

1)   Run the disk diagnostic sector uniqueness test.

   This will write every sector with its sector address
   and verify it.

2)   Dump all four RL01 units to tape, using two tapes.

3)   Run the format routine and format "all"

   This will effectively destroy the pattern on the
   disk.

4)   Restore the four RL01 units from tape.

5)   Run the disk diagnostic "verify sector uniqueness" test.

   This will verify that the information was restored
   correctly.

5.3 RUNNING DEC DIAGNOSTICS ON THE HD-11

Although the HD-11 is transparent to DEC's RL01 handler, some DEC diagnostics perform certain tests which the HD-11 cannot emulate. These tests could not be emulated exactly usually due to the physical differences between the two drives. DEC's media interchange diagnostic is the most obvious example of a test inappropriate to the HD-11.

Below is a list of DEC's RL01 diagnostics along with a list of those tests that can be run using the HD-11.

CRVLAA0:	RLVII RL01 DISKLESS	:	Tests 1-28, 30, 31
CZRLAB0:	CONTROLLER TEST 1	:	Tests 1-21, 23-31, 34-42, 44
CZRLBB0	CONTROLLER TEST 2	:	Tests 1-21, 23-34, 40-44
CZRLCB0	DRIVE TEST 1	:	Tests 1-8, 13
CZRLDB0	DRIVE TEST 2	:	Tests 2, 4-6, 8-11, 13, 14, 16, 18, 19
CZRLEB0	PERFORMANCE EXERCISER		All tests
CZRLFB0	DRIVE COMPATIBILITY	:	Does not Run

These tests are run as an RL11, because the RL11 and HD-11 do not have a maintenance mode and the RLV11 does.

If you have the more recent version of the diagnostics (CVRLAB0 and CZRLGB0 through CZRLNA0) for the RL01 and RL02, the information will be available at a later date.

Section 6

HARDWARE OVERVIEW

This section provides an overview of the major elements of the HD-11 system:
the disk drive, the power supply, the write protect switches, the circuit
breakers, the controller board, and the interface card.

6.1 THE DISK DRIVE

The Shugart Model 4008 Disk Drive is a random access storage device with
two fixed 14-inch disks as the storage media. Each disk surface has two
read/write heads and contains up to 404 data tracks. The drive provides up
to 29 megabytes of on-line storage on 1616 addressable tracks.

Low cost and reliability of the unit is achieved with a unique actuator design.
The inherent simplicity of mechanical construction and electronic controls of
the assembly allows maintenance-free operation for the life of the drive.

Mechanical and contamination protection for the head, actuator, and disk is
provided by an impact-resistant plastic enclosure. A self-contained recircu-
lating system supplies clean air through an absolute filter. The filters
are designed to last through the life of the drive.

A single track of clock information is written on the disk and read by a
single fixed head. These clock pulses are used to synchronize the Phase
Locked Loop in the data separation circuitry and provide Index, Sector and
Write Clocking information from the disk. A jumper programmable counter is
provided that converts the clock pulse into any number of sectors per track.

A data separator PCB is mounted in the drive enclosure. In addition to VFO
separation of MFM Read Data, this PCB MFM encodes and write precompensates
standardized Write Data.

6.1.1 DISK DRIVE SPECIFICATIONS

Number of Disk Surfaces	4
Number of Heads	8
Number of Cylinders	202
Number of Tracks	1616
Gross Capacity (M bytes)	29.08
Access Time (ms)	
One Track	20
Average	87
Maximum	220
Disk Speed	2964 RPM
Recording Mode	MFM
Recording Density	5534 BPI
Flux Density	5534 FCI
Track Capacity	18000 Bytes
Track Density	172 TPI
Transfer Rate	7.11×10^6 bits/sec.
	899×10^3 bytes/sec.
Sectors	60
Start Time	2 minutes

6.1.1 <u>DISK DRIVE SPECIFICATIONS</u> (continued)

Environmental Requirements

	Operating	Shipping	Storage
Temperature (host ambient)	50 to 105°F	-40 to 144°F	-8 to 117°F
Relative humidity - %	(10 to 41°C)	(-40 to 62°C)	(-22 to 47°C)
	8 to 80%	1 to 95%	1 to 95%
Maximum wet bulb		78°F non-condensing	

AC Power Requirements

    50/60 HZ $\pm$ 0.5 Hz
    100/115 VAC installations = 90 to 127V @ 3.0A maximum
    200/230 VAC Installations = 180 to 253V @ 1.5A maximum

DC Voltage Requirements

    +24 V $\pm$ 10% @ 3A maximum
    + 5 V $\pm$ 5% @ 3A maximum
    -7 to -16V @ 0.15A maximum

MTBF:	5000 power on hours
MTTR:	30 minutes
Component life:	5 years normal usage
Acoustic noise level:	less than NR 55
Error Rates:	
Soft read errors:	1 per 10^{10} bits read
Hard read errors:	1 per 10^{12} bits read
Seek errors:	1 per 10^{6} seeks
Preventative Maintenance:	none required

6.1.2 <u>DRIVE FUNCTIONAL CHARACTERISTICS</u>

The SA4000 Fixed Disk Drive consists of read/write and control electronics.
VFO data separator, MFM encode/decode electronics, read/write heads, track
positioning mechanism, drive mechanism, disk(s), and air filtrations system.
These components perform the following functions:

    Interpret and generate control signals
    Move read/write head to the selected track
    Read and write data

6.1.2 <u>DRIVE FUNCTIONAL CHARACTERISTICS</u> (continued)

The electronics are packaged on four printed circuit boards:

Read/Write PCB

1.   Read Amplifier and Transition detector
2.   Read/Write Head Selection Circuit
3.   Write Drive
4.   PLO Clock Amplifier

Actuator Drive PCB

1.   Step Buffer
2.   Head Position Actuator Driver

Control PCB

1.   Interface Drivers/Receivers
2.   Drive Select Circuits
3.   Write Fault Detection Circuits
4.   Byte (sector optional) Clock Generation Circuit
5.   Drive Ready Detector Circuit
6.   PLO Clock Detection Circuit

Data Separator PCB

1.   Data Separator
2.   MFM Encode/Decode Circuit

6.1.3 <u>ELECTRICAL INTERFACE</u>

Figure 6-1 shows the electrical connections made to the disk drives. The
electrical interface between the SA4000 and the host system is via four
connectors. The first connector, J1, provides control signals for the
drive; the second connector, J3, provides DC power, and the third connec-
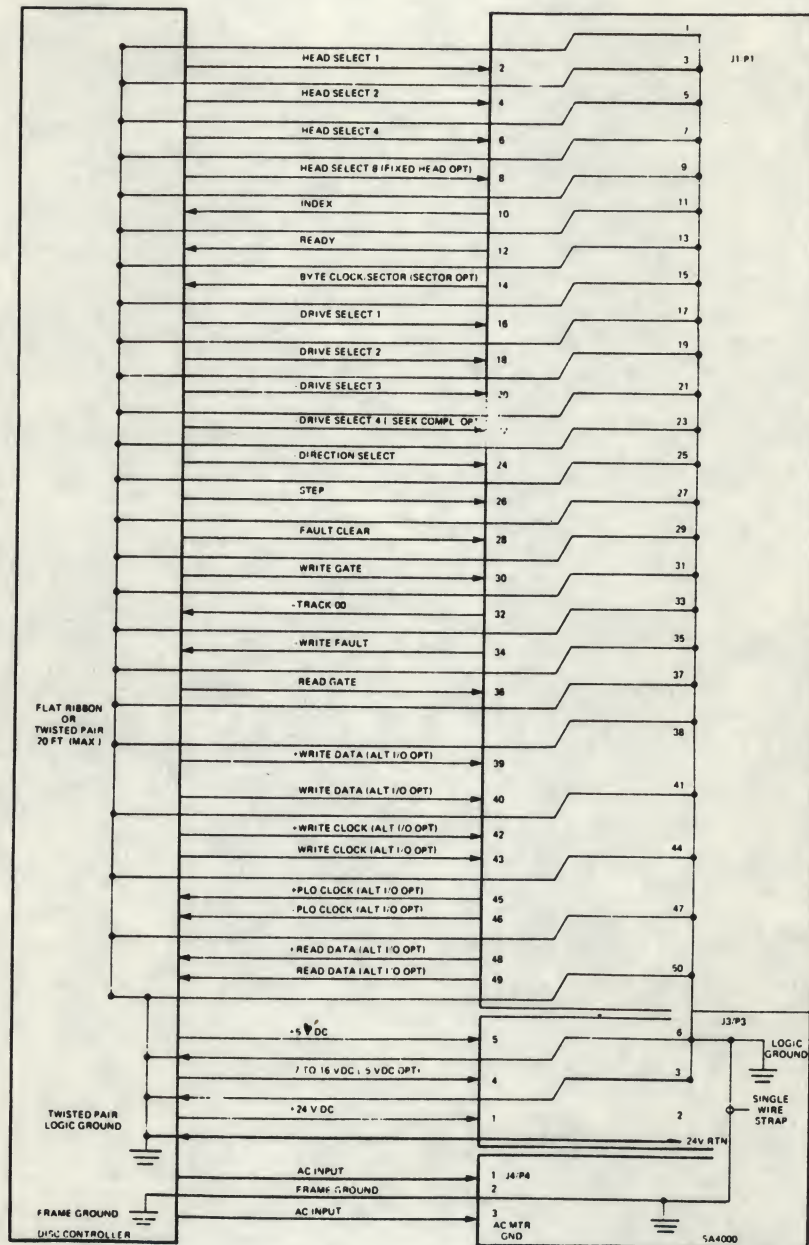tor, J4, provides AC power and frame ground.

FIGURE 6-1

6.1.4 JUMPER OPTIONS

The list below gives the correct state for all drive jumpers for use with the HD-11.

Correct State	Designator	Description
in	X	Drive always selected - normally shipped in this position.
out	DS1,2,3,4	Four drive select jumpers allow logical drive assignment.
in	ST	Allows byte clock/sector signal to be active on J1 cable. Shipped jumpered.
in	RY	Allows ready signal to be active on J1 cable. Shipped jumpered.
in	IX	Allows Index pulse signal to be active on J1 cable. Shipped jumpered.
in	T	If jumpered, allows internal delay from power on to ready active. Shipped jumpered.
in	C	If jumpered, allows seek complete signal to connect to D54 Line (single drive system). Shipped jumpered.
in	SC	If jumpered, enables sector marks to be active on byte clock line. Shipped jumpered.
out	BC	If jumpered, enables byte clock signal on byte clock line. Shipped open.
(see below)	LSB,MSB	Sector Synthesizer option (see Section 4.1.2.7 for description)

MSB	LSB
I I I O	I I O I O I O I (pin 1)

out	D	If jumpered, enables stepper motor power (+24V) with drive select (reduces power requirements in multiple drive system). Shipped open.
in	E	This leaves stepper motor power continuously enabled. Shipped jumpered.
out	SI	If jumpered, masks sector pulse at index pulse time (see Figure 14). Shipped jumpered.
in	S2	If jumpered, enables sector pulse at index pulse time (see Figure 14). Shipped open.

6.1.4 <u>JUMPER OPTIONS</u> (continued)

Correct State	Designator	Description
in	4H	16-pin jumper shunt allows - write clock, write data, read data, and PLO clock to be active on the J1 cable (single drive system). Shipped with shunt.
out	R	If jumpered, connects ready line to LED. Shipped open.
out	S	If jumpered, connects drive select to LED. Shipped open.
out	F	If jumpered, connects write fault to LED. Shipped open.
in	SL	If jumpered, enables the following I/O signals when drive select is active: index, ready, and byte clock. If jumper is removed, these signals are continuously active. Shipped jumpered.
in	C	If jumpered, data separator will synchronize on field of zeroes. Shipped jumpered.
out	D	If jumpered, data separator will synchronize on field of ones. Shipped open.

WARRANTY

CHARLES RIVER DATA SYSTEMS, INC.

All equipment purchased directly from CRDS, it's authorized representatives and/or franchised Distributors is warranted on "return-to-factory" basis against defects in workmanship and materials under normal and proper use in its unmodified condition for a period of ninety (90) days from date of initial shipment. As a condition of this warranty, Customer must (a) obtain a CRDS Return Authorization (RA) number, (b) ship the equipment (or sub-assembly) to the designated CRDS Repair point, transportation prepaid, and (c) include with the returned equipment (or sub-assembly) a WRITTEN description of the claimed defect. Transportation charges for the return to Customer of in-warranty repaired equipment (or sub-assembly) shall be paid by CRDS within the fifty (50) United States, District of Columbia, and Canada. Returns to customer of out-of-warranty repaired equipment (or sub-assembly) shall be "Transportation Collect". If CRDS determines that the equipment (or sub-assembly) returned to it for warranty correction is not defective as herein defined, Customer shall pay CRDS all costs of handling and transportation. All repaired or replaced equipment shall be returned only to Customer and not to third parties to whom Customer may have sold, leased or otherwise transferred the equipment. The warranties provided herein are exclusive to the Customer only.

Charles River Data Systems, Inc., hereby warranties all equipments (or sub-assemblies) of first party manufacturers and/or their authorized, franchised representatives and distributors against defects in workmanship and materials, only to the full limits and extent that such items are warranted to CRDS.

<u>This warranty is expressed in lieu of all other merchantability warranties expressed or implied (including the implied warranty of fitness for a particular purpose) and of all other obligations or liabilities on CRDS's part, and CRDS neither assumes nor authorizes any other person to assume any other liabilities in connection with the sale of the said article.</u>

RETURNING MATERIAL

IN THE EVENT THAT IT BECOMES NECESSARY FOR YOU TO RETURN MATERIAL
TO CHARLES RIVER DATA SYSTEMS, PLEASE:

1.   Phone the factory in advance of your return.

      When you call, please have available:

      a. A description of the problem or reason for
         the return.

      b. The serial number of the unit.

      c. Your original purchase order number, CRDS
         invoice number, or shipping memo number.

2.   Obtain a Return Authorization (RA) Number from CRDS.

3.   Show the RA Number on all packages shipped to CRDS.

      Parcels which are not marked with an RA Number may be
      refused at the factory. You should reference this
      number in all communications concerning the returned
      goods.

4.   Enclose a description of the problem or any other
      information which may help in expediting repair of
      the unit.

Please note that a new purchase order number will be required whether
the unit is in warranty or out of warranty.